ENGINEERING PHYSICS LAB MANUAL CUM OBSERVATION

FOR

ELECTRONICS & COMMUNICATION ENGINEERING

Sir C.V. RAMAN LABORATORY FOR EXPERIMENTAL PHYSICS

DEPARTMENT OF PHYSICS

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

An Autonomous Institution

Approved by AICTE & Permanently Affiliated to JNTUK, Kakinada

Accredited by NAAC with “A” Grade and NBA (ECE,CSE, EEE & ME)

Jonnada (Village), Denkada-(Mandal), Vizianagaram Dist – 535 005

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VISION & MISSION OF THE INSTITUTE

VISION

Producing globally competent and quality technocrats with human values for the holistic needs of industry and society

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.
- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.
- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION

Emerge as a Center of Eminence in Electronics and Communication Engineering to impart quality education towards competent and skilled engineers.

MISSION

- Offering an inspiring and conducive learning environment to prepare skilled and competent engineers by having good infrastructure, laboratory facilities and effective teaching-learning process.
- Fostering culture to face complex technological challenges through Internships, projects and Industry-Institute Interactions in order to enhance employability skills.
- Creating an environment for higher studies and entrepreneurship by way of imparting quality education and promoting research activities.
- Imparting professional behavior and strong ethical values towards societal issues by encouraging socially relevant activities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will have strong knowledge, skills and attitudes towards employment, higher studies and research.

PEO2: Graduates shall comprehend latest tools and techniques to analyze, design and develop novel systems and products to solve real life problems.

PEO3: Graduates shall have multidisciplinary approach, professional attitude, ethical values, good communication, team work and engage in life-long learning to adapt the rapidly changing technologies.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Capable of design, develop, test, verify and implement analog and digital electronics and communication engineering systems and products.

PSO2: Qualify in national and international competitive examinations for successful higher studies and employment.

PROGRAM OUTCOMES (POs)

PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-Long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OBJECTIVES

1. To impart the practical knowledge in basic concepts of Wave optics, Lasers and Fiber optics and Semiconductor physics

2. To familiarize the handling of basic physical apparatus like Vernier callipers, screw gauge, spectrometers, travelling microscope, laser device, optical fibres, etc.

COURSE OUTCOMES

1. Apply the working principles of laboratory experiments in optics, electrical and electronics (L3)

2. Compute the required parameter by suitable formula using experimental values (observed values) in optics, electrical and electronics experiments. (L3)

3. Analyze the experimental results through graphical interpretation. (L4)

4. Recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory. (L2)

5. Demonstrate the working principles, procedures and applications. (L3)

COs – POs & PSOs MAPPING (ECE)

SNO	DESCRIPTION	PO(1..12) MAPPING	PSO(1..2) MAPPING
CO1	Apply the working principles of laboratory experiments in optics, electrical and electronics. (L3)	PO1, PO2, PO9, PO12	PSO1
CO2	Compute the required parameter by suitable formula using experimental values (observed values) in optics, electrical and electronic experiments. (L3)	PO1, PO2, PO9	PSO1
CO3	Analyze the experimental results through graphical interpretation. (L4)	PO1,PO2, PO9, PO12	PSO1
CO4	Recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory. (L2)	PO1,PO2, PO5,PO6,PO9	PSO1
CO5	Demonstrate the working principles, procedures and applications. (L3)	PO1, PO2,PO5, PO6,PO9,PO12	PSO1
COURSE OVERALL PO/PSO MAPPING: PO1, PO2, PO5,PO6,PO9,PO12, PSO1			

COs – POs & PSOs LEVEL OF MAPPING & JUSTIFICATION

SNO	PO 1	P O2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	P O9	PO 10	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	1							2			1	1	
CO2	3	1							2				1	
CO3	3	1							2			1	1	
CO4	3	1			1	1			2				1	
CO5	3	1			1	1			2			1	1	
R20BSH-PH1202	3	1			1	1			2			1	1	

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1)**:**

COs VS POs MAPPING JUSTIFICATION:

S.NO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
CO1	PO1	3	The student can able to apply the working principles of laboratory experiments of optics, electricals and electronics.
	PO2	1	The student can able to idetify suitable formula of laboratory experiments for computing the required parameter.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to identify the procedure of laboratory experiments.
	PO12	1	The student can able to utilize this basic experimental knowledge for further designing & development in the career.
	PSO1	1	The student can able to use this experimental knowledge for further designing, development & testing of the electronics and communication engineering systems and products.
CO2	PO1	3	The student can able to apply the working principles of laboratory experiments of optics, electricals and electronics.
	PO2	1	The student can able to compute the required parameter by suitable formula of laboratory experiments.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to compute the required parameter of laboratory experiments.
	PSO1	1	The student can able to use this experimental knowledge for further designing, development & testing of the electronics and communication engineering systems and products.
CO3	PO1	3	The student can able to apply the knowledge of optics, electricals and electronics to analyze the experimental results through graphical interpretation.
	PO2	1	The student can able to analyze the experimental results through graphical interpretation.

	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to analyze the experimental results through graphical interpretation.
	PO12	1	The student can able to utilize these fundamental principles, procedures and applications life long for the improvement.
	PSO1	1	The student can able to use this experimental knowledge for further designing, development & testing of the electronics and communication engineering systems and products.
CO4	PO1	3	The student can able to apply the knowledge of optics, electricals and electronics to recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory.
	PO2	1	The student can able to identify the required precautions to carry out the experiment and handling the apparatus in the laboratory.
	PO5	1	The student can able to apply the basic knowledge of Lasers & optical fibers as modern engineering tools in the career.
	PO6	1	The student can able to use the basic knowledge of Lasers & optical fibers in the health relevant applications.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to recognize the required precautions to carry out the experiment and handling the apparatus in the laboratory.
	PSO1	1	The student can able to use this experimental knowledge for further designing, development & testing of the electronics and communication engineering systems and products.
CO5	PO1	3	The student can able to apply the knowledge of optics, electricals and electronics to demonstrate the working principles, procedures and applications of experiments through viva-voce.
	PO2	1	The student can able to demonstrate the working principles, procedures and applications of experiments through viva-voce.
	PO5	1	The student can able to apply the basic knowledge of Lasers & optical fibers as modern engineering tools in the career.
	PO6	1	The student can able to use the basic knowledge of Lasers & optical fibers in the health relevant applications.
	PO9	2	The student can able to understand how to work in a team as a member by sharing his ideas; thoughts & knowledge to demonstrate the working principles, procedures and applications of experiments through viva-voce.
	PO12	1	The student can able to utilize these fundamental principles, procedures and applications life long for the improvement.

	PSO1	1	The student can able to use this experimental knowledge for further designing, development & testing of the electronics and communication engineering systems and products.
R20BSH-PH1202	PO1,PO2 PO5,PO6 PO9,PO12, PSO1	3,1,1,1,2,1,1	The student can able to acquire knowledge of basic experiments on Engineering Physics and apply these principles & knowledge in his/her engineering course.

L	T	P	C
0	0	3	1.5

List of Experiments

(As Per autonomous syllabus of Lendi Institute of Engg & Technology)

1. Determination of thickness of of fibre (thin paper/piece of hair) using wedge shaped film.
2. Determination of the radius of curvature of the lens by Newton's rings method.
3. Determination of wavelength of of mercury light by plane diffraction grating.
4. Determination of wavelength of laser light by normal incidence method.
5. Determination of the Numerical Aperture of a given Optical Fiber & find its acceptance angle.
6. Determination of the energy band gap of a given semi-conductor.
7. Determination of the temperature co-efficient of resistance of a given Thermistor.
8. Determination of the resolving power of grating.

Virtual Physics Lab Experiments

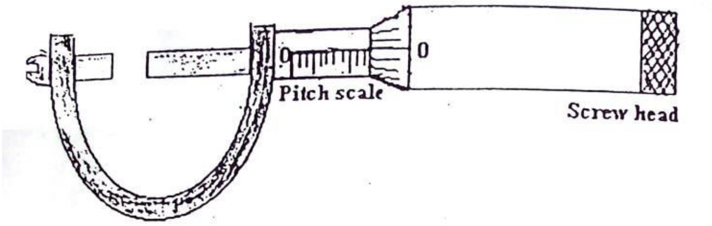
9. Determination of the Brewster's angle.
10. Determination of the Hall coefficient & the carrier concentration of charge carriers in the given sample materialby Hall Effect.

Instructions for Students@ Engineering Physics Laboratory

- The objective of the laboratory is learning (application point of view). The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments. Conduct the experiments with interest and an attitude of learning.
- You need to come well prepared for the experiment.
- Work quietly and carefully (the whole purpose of experimentation is to make reliable measurements & to experience the application based analytical thinking) and equally share the work with your partners.
- Be honest in recording and representing your data. Never make up readings or manipulate them to get a better fit for a graph. If a particular reading appears wrong repeat the measurement carefully. In any event all the data recorded in the tables have to be faithfully displayed on the graph.
- Bring observation book cum manual and necessary graph papers for each of experiment. Learn to optimize on usage of graph papers.
- Graphs should be neatly drawn with pencil. Always label the graphs, the axes and display units. Please write the scale at the top-right most corner of the graph paper.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs.
- Come equipped with calculator, pen, scale, pencil, eraser, sharpener, etc.
- Get the signature from your Lab Faculty before leaving the lab on your observation book. And also submit your pending calculations & graph works within two days after completion of your lab.
- Do not fiddle idly with apparatus. Handle instruments with care. Report any breakage to the Lab-Technician/ Faculty.
- Return all the equipment at the end of your experiment.
- Bring your records at each lab session & submit it for the correction of previously completed experiments.

SCREW GAUGE

It is an instrument used for the measurement of very small lengths (such as the diameter of a wire and thickness of a disc) with greater accuracy than is possible with Vernier calipers. The screw gauge consists of U-shaped metal frame which is attached to a hallow cylinder with a screw head. The screw head has a cap which is marked with 100 equal divisions. This is called Head scale. The hallow cylinder is marked in millimeters called Pitch scale. The distance advanced on the pitch scale when the screw head is turned through one complete revolution is called the pitch of the screw. Least count of the screw gauge is the distance advanced by the screw when the screw is turned through one division on the head scale.



L.C of the screw gauge = pitch of the screw/No of Head scale divisions.

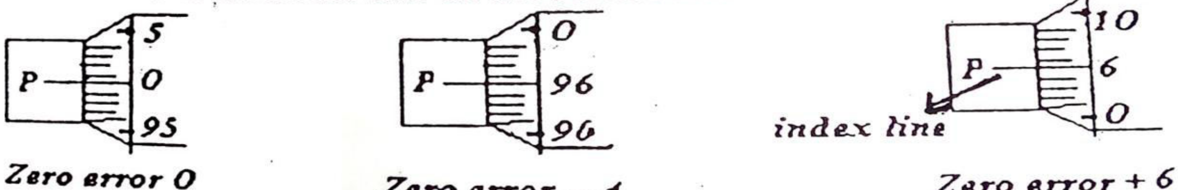
Pitch of the screw = Distance moved on the pitch scale for one rotation of the head.

The distance is divided by 5 gives the value of the pitch of the screw. Again the pitch of the screw is divided by the number of head scale divisions and the resulting value is the least count of the screw gauge.

The screw head is turned until the two jaws touch each other. If the zero of the head scale exactly coincides with the zero of the pitch scale line (called index line) then there is no zero error and no correction is to be made to the head scale reading. If they do not coincide then the instrument is said to have zero error and a correction is to be applied. In fig (a) the zero of the head scale coincides with the pitch scale line and hence correction is zero. If the zero division of the head scale is above the pitch scale line then the error is negative and the correction is positive. In fig (b) the zero of the head scale is 4 divisions above the index line, hence the error is -4 and the correction is +4. Therefore 4 must be added to the head scale reading.

In fig(c) zero of the head scale is below index line the error is +6 and correction is -6 which means that 6 must subtracted from the head scale reading.

P is the index line on the pitch scale



Zero error 0
Correction 0
Fig (a)

Zero error – 4
Correction + 4
Fig (b)

Zero error + 6
Corrction – 6
Fig (c)

Place the given object between the two jaws of the screw gauge and the screw head is turned gently until the two jaws touch the object. Note down the pitch scale reading (PSR) and head scale division opposite to the pitch scale index line called head scale reading (HSR). Correct the head scale reading (CHSR) in case the correction is not zero. Then

Total reading = PSR + (CHSR x Least count)

The process is repeated at three different locations along the length of the wire and determines the average diameter of the wire or thickness of given object.

VERNIER CALIPERS

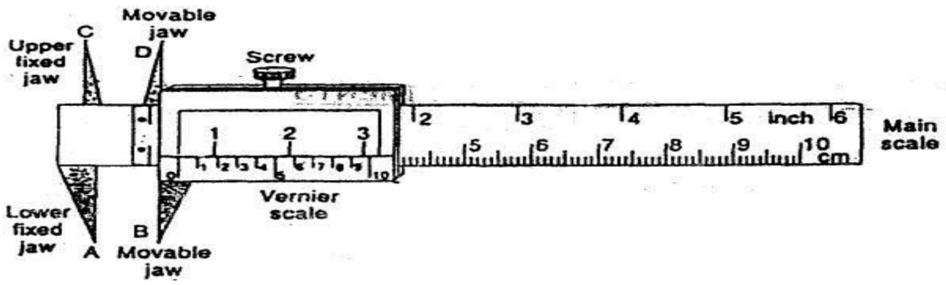
A scale is used to measure the length of an object. One end of the object is made to coincide with the zero of the scale, the other end of the object falls between the fifth and sixth divisions. This means that the length of the object is greater than 5 divisions and less than 6 divisions. So the length of the object is 5 divisions plus some fraction of a scale division. An accurate measurement of this fractional length can be made by means of Vernier calipers and screw gauge.

A Vernier caliper is an instrument used for the measurement of small lengths such as diameter of a disc and diameter of a bob. The vernier calipers consist of a rectangular metal strip, graduated in centimeters, with a fixed jaw at one end. This is called main scale. A movable jaw with Vernier attached to it slides along the main scale and can be fixed at any position with a screw. This is called Vernier scale. The Vernier scale is graduated in such a way that the length of 10 divisions on the Vernier scale (VSD) is equal to length of 9 main scale divisions (MSD). Thus the length of 1 VSD = 9/10of the MSD. Then the difference between one MSD and one VSD is 1-9/10) MSD= 1/10 MSD, which is called the Least count of the Vernier calipers. The least count of Vernier calipers of an instrument is the smallest value that can be measured with that instrument.

1 MSD = 1/10 cm;   10VSD= 9 MSD or 1 VSD = 9/10 MSD

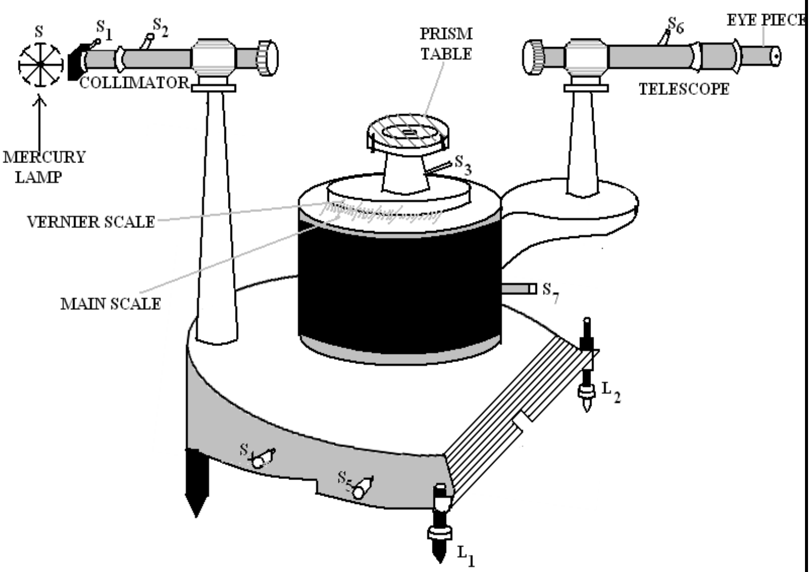
Least count of Vernier calipers = 1MSD – 1 VSD = (1-9/10) MSD = 1/10 MSD

= (1/10) x 1/10 cm = 1/100 cm = 0.01 cm



Least count can also be expressed as 1 MSD/No. of Vernier scale divisions.
Suppose the length of the object is to measure using Vernier calipers. The object is placed between the fixed jaw and movable jaw. Suppose the zero of the Vernier lies between 1.7cms and 1.8 cm. This means the length of the object is greater than 1.7 cm and less than 1.8 cm. The fractional part exceeding 1.7cm (called main scale reading MSR) can be determined from the Vernier coincidence. Suppose the 4 division on the Vernier exactly coincides with one of the main scale divisions. This Vernier division which coincides with the main scale division is called Vernier coincidence. So the fraction exceeding the 1.7cm is (4 MSD- 4 VSD). This fraction is equal to 4 (1MSD-1VSD) = 4xLeast count. Therefore the length of the object = MSR + (Vernier coincidence x L.count)= 1.7 cm + 4 x 0.01 cm = 1.74 cm

SPECTRO METER



Align the spectrometer in order to correctly measure angles with the spectrometer, we must first align it. To do so, use the following steps:

a) **Telescope focus:** Do not put the prism onto the silver table yet. That will come later. Notice that there are two knobs associated with the telescope. They are located directly under the telescope barrel. One points along the barrel and one is perpendicular to it. The knob that is along the barrel will lock the telescope's position and will prevent it from rotating. When it is locked down in this way, you can use the other knob for a fine adjustment, to rotate it by very small amounts. If the telescope is not unlocked, turn the knob that is parallel to the barrel counterclockwise until you can freely rotate the telescope. Turn the telescope so that it is not pointing at the collimator but is instead aimed at something as far away from you in the room as possible. Now rotate the focus adjustment (**see diagram on page 12**) until you can see through the telescope clearly. You may notice that the image is upside down. This is normal. Just ensure that it is as clear and in focus as you can. ***After this adjustment, you should not adjust the focus of the telescope again***.

b) **Telescope alignment**: Now place a white light (desk lamp) in front of the slit on the end of the collimator (**in the diagram on page 12)**, the desk lamp goes where the "HG lamp" is pictured). Now rotate the telescope until it is pointed at the collimator. You should imagine a straight line going from the lamp through the collimator, and through the telescope. By looking through the telescope, you should be able to line up the crosshair with the slit in the far end of the collimator. By locking down the telescope and using the fine adjustment (the knob perpendicular to the one that you used to lock down the telescope) you should be able to do this very accurately.

   If you are unable to see the slit, it may be closed too tightly. You can widen and narrow the slit by rotating the adjuster on the collimator (it is located on the far end of the collimator, much like the focus for the telescope). This will adjust the slit width, but will not focus the slit. If the slit does not have very crisp edges when you look through the telescope, move the end of the collimator near the lamp in and out to focus it. If your slit is not vertical in the telescope, you can also rotate it so that it is. Once you have a nice thin, well-focused slit, with your crosshairs centered on it **and your telescope locked down**, you are now ready to align the scales to read the angle.

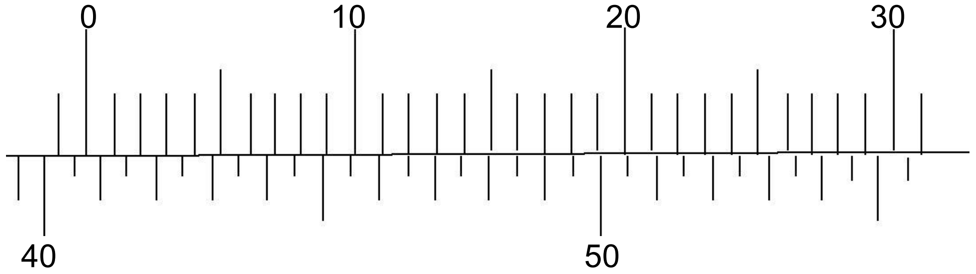
c) **Angle adjustment**: If you look below the set of knobs that control the telescope, you will see another pair of knobs that look identical to the ones for the telescope. These knobs perform the same functions (locking down and fine adjustment) for the black table itself. If you unlock the black table, you can rotate it. Notice that there are two windows in which you can read an angle. We want to rotate the table until one of the windows has 0 (zero) lined up with 0 (zero) or 360 (since a circle is 360 degrees, 360 is the same as 180. If at all possible, we should try to use set it so that this window is to the left of the telescope (as we are looking over the barrel toward the lamp) because this will make reading our angle easiest. (Please have a look at the diagram on page 5) On some scopes there is a small magnifier attached to the black table over one window, and this would also be advantageous to use. Once you have aligned them, you will ***lock down the black table and will not rotate it again***. From now on, we will ***only rotate the telescope.***

d) **Prism placement**: Now you should place the prism in the center of the silver table. Recall that light is bent toward the base of the prism, so it should be placed on the silver table so that the gray plastic part makes a "C" shape if you were to look at it from the telescope side of the apparatus. Now, without moving the telescope, move your head to the left (about to where the telescope is rotated to in the diagram on page 5) and look into the prism. You will have to put your head down at the height of the telescope/collimator. Now rotate the silver table clockwise until you can see a nice rainbow like spectrum “inside” the prism. (You should notice that the rainbow is inside of a black circle. You are seeing the light coming out of the collimator and bent through the prism.) If it does not look like a very nice, bright, well formed rainbow, you probably do not have your head in the right place; move further left and try to rotate the silver table back and forth. Once you have found it, unlock the telescope (**not the black table**) and rotate it **to the left** where you were looking. Now look through the telescope, and you should be able to find the rainbow. We are now in about the right place to find our spectrum with the mercury vapor lamp and to adjust for the minimum angle of deviation.

e) **Minimum angle of deviation**: Now, remove the white light and replace it with the mercury vapor lamp. You will want to move the lamp until it is aligned with the slit. To do this, look through the telescope and move the lamp back and forth until it is nice and bright in the telescope. **Instead of a complete rainbow, you should now see only certain bands of colors**. If your bands do not look nice and sharp, you may have to adjust your slit focus or width. Some lines are better seen if you tighten the slit. (The lamp should be very close to the slit.) Move the telescope back and forth until you get the cross hair lined up on the **green band**. Now look back to the diagram on page 12. We want to make the angle as small as possible. To do this, rotate the silver table back and forth just a little bit. You should be able to get the green line to move **to the right**. Now realign the crosshair on the green line and rotate the silver table a little bit again. Then realign the crosshair on the green line. You should repeat this process until no matter which way you rotate the silver table, the green line goes to the left, not the right. When this occurs, and the green line is as far as you can get it to go to the right, you are at the minimum angle of deviation. This angle should be around 51 or 52 degrees for the green line. If it is not, you may not have aligned the scales correctly, please repeat steps c, d, and e from above. (Record it below). Every time that you do a different color, you will have to repeat this process.

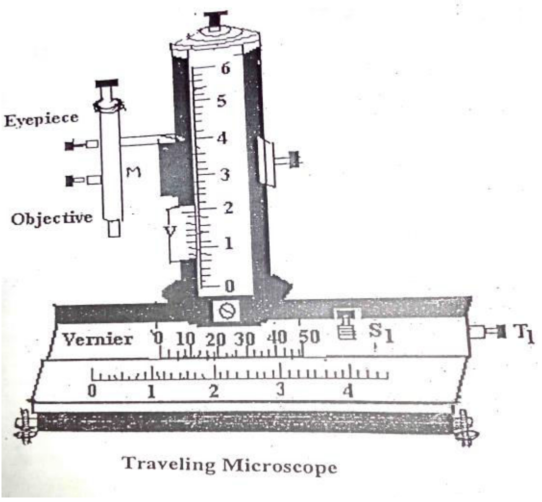
PROCEDURE: Become familiar with the spectrometer identify each component: the black table, the prism table, the collimator, and the telescope (see figure above). Note the clamping screws and the fine adjustment screws for the telescope and the black table. Note the clamping screw for the prism table. Note how to adjust the slit focusing in the collimator tube. Note how the slit width can be adjusted and how the slit orientation can be rotated

Practice reading the angle from a precise protractor scale on the rim of the black table. Use the Vernier scale with the little magnifying glass to read the angle to the nearest arc minute. (1 arc min = 1' = 1/ 60 degree.) **The following is an example**:



In this example, the zero line of the Vernier scale (the upper scale) is between 40° 30' and 41°, so the angle is somewhere between 40° 30' and 41°. The Vernier scale tells exactly where in between. Look along the Vernier for the line that exactly lines up with the line below it. In this case, it's the 17' line. So the angle is 40° 47', which we get by adding 17' to 40° 30'. Before using this angle in equation (2), we must convert it to decimal degrees: 40 + (47/60) degrees = 40.78°.

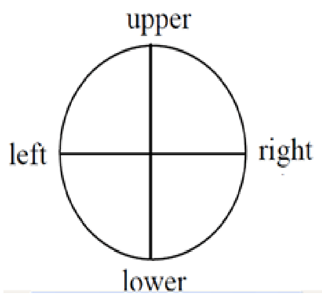
A Travelling Microscope



Traveling Microscope

A travelling microscope is used to determine small distance to an accuracy of **0.001 cm**. The measurement principle is based on the principle of Vernier. In a typical travelling microscope, the main scale divisions are of magnitude **1/20 cm = 0.05 cm (0.5 mm)** each and the Vernier scale contains 50 divisions. This makes the Least Count to be **0.05/50 = 0.001 cm.**

Determination of diameter: For determination of diameter of the capillary along the horizontal direction. Mount the capillary tube in horizontal direction in a stand with the help of a rubber cork to place and hold the capillary tube. Rotate the microscope so that it is horizontal and in line with the tip of the capillary tube. Now looking through the microscope, turn the focusing screw to get a clear image of the capillary tube. Now adjust the microscope in such a way that the vertical crosswire coincides with the left end of the capillary tube. Take the reading in the horizontal scale, look the zero of the Vernier, and find out the division on the main scale just before the zero mark. Note it as the MSR. Now look carefully at the Vernier. Any one of the fifty lines will come exactly in line with one of the lines of the main scale. That division on the **Vernier** is the Vernier scale reading. Note it down in the observation table. Now move the telescope horizontally to focus on the right end of the capillary tube. Again take the reading as before. Repeat the experiment by moving the telescope vertically coinciding the horizontal crosswire with top and bottom and now the readings are taken on the vertical scale. From the observations you will get two values of diameter, one for vertical and one for the horizontal.



Total reading = Main scale reading + Vernier coincidence x Least count

OBSERVATIONS: Least count of the traveling microscope = 0.001 cm

BACK – LASH EROR:

This error occurs when instruments like screw gauge, speedometer and travelling microscope are used, which work on screw-nut principle. Due to wear and tear of the screw or imperfect fitting, some space will be left between the screw and nut for its operation. If the screw is rotated for a certain angle of rotation in the forward direction and afterwards in the backward direction, then the screw will not move for a little motion of the head of the screw (or the misfits in the nut through which it moves). This error is called back-lash error. In order to avoid this error, the screw must always be moved in the same direction. This is to be remembered whenever we use any instrument using / involving screw motion.

Experiment No:
Date:

EXPERIMENT NO – 1

THERMISTOR

AIM: To determine the temperature coefficient of resistance of a given Thermistor

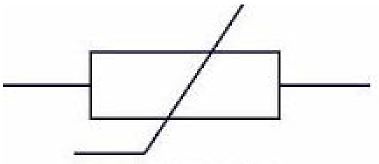
APPARATUS

A Thermistor, thermometer, a heating arrangement to heat the Thermistor, constant current power supply, galvanometer, millimeter and volt meter

WORKING PRINCIPLE: ***Thermally Varying Resistance:*** The basic the electrical resistance of the device changes drastically when the temperature is varied. These devices are called thermistor because of their thermally sensitive property of resistance. These materials have a negative temperature coefficient of resistance.

Formula:

The temperature coefficient of resistance of Thermistor is



Thermistor Symbol

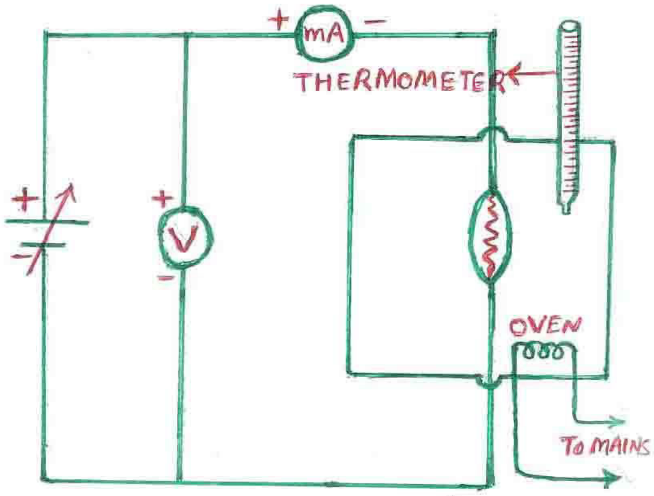
$$\alpha = \frac{R_2 - R_1}{R_1T_2 - R_2T_1} \ /^0C$$

Where R_1 and R_2 are the resistances of thermistor and T_1 and T_2 are temperatures

THEORY:

Thermistors are semiconductor devices. The basic property is the electrical resistance of the device changes drastically when the temperature is varied. These devices are called thermistor because of their thermally sensitive property of resistance. Thermistor materials are mainly ceramic compounds having semiconductor properties. They are made up of oxides of Mn, Ni, Fe and Co and blended in suitable proportion and compressed in to desired shapes from powders and heat treated to re crystallize them, Suitable combination of these oxide materials are used to obtain the necessary range of resistance. Conduction is controlled by the concentration of the oxygen in the semiconductors. N-type oxide semiconductors are produced when the metal oxides are compounded with deficiency of oxygen.

Circuit diagram:



Because of this process there will be excess ionized metal atoms in the lattice. P-type semiconductors are produced when there is excess of oxygen, which results in deficiency of ionized metal atoms in the lattice. 'α' is called the temperature coefficient of resistance for a given material.

It is positive for metallic elements as their resistance increases with temperature. Hence the materials have a positive temperature coefficient of materials. On the other hand α is negative for carbon and semiconductors because their resistance which decreases with increasing temperature. These materials have a negative temperature coefficient of resistance.

FORMULAE:

The variation of resistance (R) of a thermistor with temperature (T) is given by,

$$R = A\, e^{\frac{B}{T}} \qquad \text{---------} \quad (1)$$

where 'A' and 'B' are constants, which are to be experimentally determined,' R' is the resistance of the thermistor and 'T' is the temperature.

Taking logarithm on both sides, we get

$$\log_{10}R = \log_{10}A + \left(\frac{B}{2.303}\right)\frac{1}{T} \qquad (2)$$

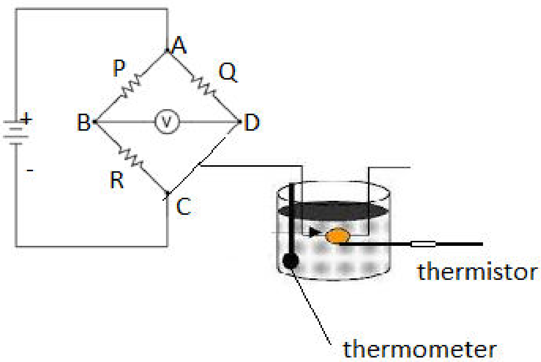
Now the temperature coefficient of resistance 'α' of the thermistor is given by,

$$\alpha = \frac{1}{R}\frac{dR}{dT} = -\frac{B}{T^2} \qquad (3)$$

Evidently, α is negative (as expected) and is also temperature dependent.

The temperature coefficient of thermistor materials is many orders of magnitude greater than that of metals. From (2),

Experimental diagram



$$\mathrm{Log}_{10}R = \log_{10}A + \left(\frac{B}{2.303x10^3}\right)\frac{10^3}{T} \qquad (4)$$

This is in the form y = mx + c where the slope **m =** $\frac{B}{2.303x10^3}$ (5)

Taking the value of B from the above equation (5), the activation energy can be determined as follows

$$E_g/2k = B \quad \text{or} \quad E_g = 2KB \qquad (6)$$

The temperature resistance characteristics of the thermistor exhibits an exponential type of behavior and it is given by the relation

$$R = R_0 \exp\left[B\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$$

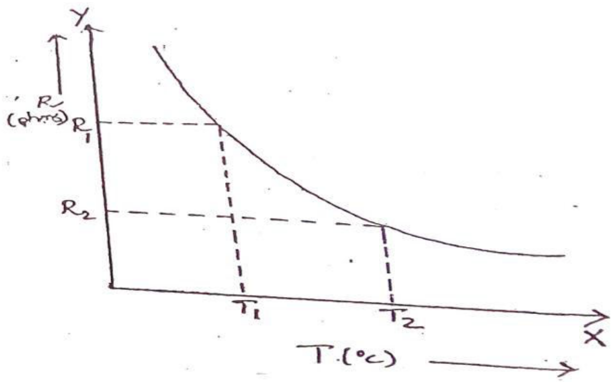
If we differentiate this equation we get,

$$\frac{\Delta R}{\Delta T} = R_0 \exp\left[B\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]\frac{-B}{T^2}$$

But $\frac{1}{R}\frac{\Delta R}{\Delta T}$ = α, where $\alpha = \frac{-B}{T^2}$

GRAPH:

A plot drawn between log R on y-axis and $10^3/T$ on x-axis gives a straight line and slope of this line is equal to $B/2.303x10^3$.By measuring the slope of the graph we can determine the value of B.



The intercept (OP) along the y-axis as shown in the model graph gives the value of log A from which the value of 'A' is calculated.

From the graph temperature coefficient of resistance 'α' can be calculated using the formula

$$\alpha = \frac{R_2 - R_1}{R_1 T_2 - R_2 T_1} \ /^0C$$

Where R_1 and R_2 are the resistances of the thermistor at the temperatures T_1 and T_2 respectively.

PROCEDURE:

1. Connect the +5V power supply to power supply socket and galvano or Voltmeter socket
2. Also connect the variable resistance (0 to 1000 Ω) to variable resistance socket and thermistor terminal to thermistor socket which are given on heater.
3. Put up the thermistor to heater where the thermistor keeps up option
4. Switch on the kit and set the galvanometer to zero by variable resistance. Switch on the heater
5. As soon as the temperature increases i.e. 30^0C, 35^0C, 40^0C, 45^0C, 50^0C, 55^0C, 60^0C, 65^0C, 70^0C and 75^0C the value of resistance is found by multimeter. (Suppose the temperature is 40^oC, now the galvanometer shows some deflection now decrease it to zero by variable resistance and take reading of resistance by multimeter. This is the reading of R at 40^oC. Similar take readings for different temperatures).
6. Note down the readings & Plot the graph between R Vs T(K).

OBSERVATIONS: **Input Voltage V_i =**

SNo	Temperature t (^{0}C)	Current (I) mA	Temperature T = t + 273 (K)	$\frac{1000}{T}$ (K^{-1})	Resistance R KΩ	Log R
1	30^0					
2	35^0					
3	40^0					
4	45^0					
5	50^0					
6	55^0					
7	60^0					
8	65^0					
9	70^0					
10	75^0					

APPLICATIONS:

1. Thermistor can be used as current-limiting devices for circuit protection, as replacements for fuses. Current through the device causes a small amount of resistive heating. If the current is large enough to generate more heat than the device can lose to its surroundings, the device heats up, causing its resistance to increase, and therefore causing even more heating. This creates a self-reinforcing effect that drives the resistance upwards, reducing the current and voltage available to the device.
2. Thermistors are used for Self regulating heaters, Liquid level sensing, Motor starting.
3. Thermistors are used as resistance thermometers in low-temperature measurements of the order of 10 K.
4. Thermistors are regularly used in automotive applications. For example, they monitor things like coolant temperature and/or oil temperature inside the engine and provide data to the ECU(Engine Control Unit).
5. Thermistors are also commonly used in modern digital thermostats and to monitor the temperature of battery packs while charging.

PRECAUTIONS:

1. The thermistor and thermometer are kept at the same level in the oil bath.
2. The temperature of the thermistor should not be allowed to go beyond 80^0 C.

CALCULATIONS:

RESULT: The temperature coefficient of resistance of the given Thermistor is =

Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PS01** are attained.

Signature of Faculty with date & Remark

VIVA QUESTIONS

1. **What is a thermistor?**
   Thermistor is a semiconductor material usually prepared from metal oxides who's electric resistance changes drastically for even minute changes in temperature.

2. **What is positive temperature coefficient of resistance?**
   A positive temperature coefficient (PTC) refers to materials that experience an increase in electrical resistance when their temperature is raised. e.g. all conductors

3. **What is negative temperature coefficient of resistance?**
   A negative temperature coefficient (NTC) refers to materials that experience a decrease in electrical resistance when their temperature is raised. e.g. semiconductors

4 **What is the difference of semiconductor diode and thermistor?**
In a semiconductor the carrier concentration depends on temperature but the carrier concentration is temperature independent in case of thermistor. The variation of electrical resistance in thermistor with temperature is due to only the thermal activation of charge carriers with increase of temperature.

5 **What is activation energy?**
The quantity of energy required for the electric conduction to take place in a thermistor is called as the activation energy.

Experiment No:
Date:

EXPERIMENT NO - 2

NEWTON'S RINGS

AIM: To determine the radius of curvature of given Plano-convex lens by Newton's rings method

APPARATUS: A Plano-convex lens, piece of thick glass plate, thin glass plate, sodium vapour lamp, traveling micro scope and black sheet.

WORKING PRINCIPLE: ***Interference of Light:*** The light reflected from the upper and lower surfaces of thin air film formed in between the lower surface of convex lens and upper surface of glass plate.

FORMULA: The Newton's rings experiment is an example of interference of light by division of amplitude in reflected light according to the theory of Newton's rings, the diameter of the mth dark ring is given by $D_m=2\sqrt{m\lambda R}$ where m=,1,2.. etc and diameter of the nth dark ring is $D_n=2\sqrt{n\lambda R}$ where n=0,1,2.. etc

Therefore, $D_m^2-D_n^2=4m\lambda R-4n\lambda R$ or

$$R=\frac{D_m^2-D_n^2}{4\lambda(m-n)}\,cm$$

Where,

R is the radius of curvature of the lens in constant with the glass plate (cm)
D_m and D_n are the diameters of the mth and nth dark rings respectively (cm)
m, n are the number of chosen rings
λ is the wavelength of the monochromatic source of light(sodium light)
(λ=5893 A^0 =5893 X 10^{-8} cm)

Concentric ring system is formed because the path difference between the two interfering light rays is constant radially or the locus of all points having the same air gap is a circle.

The values of D_m and D_n are small and are measured accurately with the traveling microscope. It can be seen from the formula that the diameter of the ring increases with the radius of curvature R. Therefore it is desirable to select a suitable convex lens of long focal length for forming rings. The diameter of the bright fringes is proportional to the square root of the natural numbers.

D_n (bright) $= \sqrt{(2n-1)\lambda R}$

D_n (dark) $= 2\sqrt{n\lambda R}$

ARRANGEMENT OF APPARATUS:

Clean the surface of the convex lens and thick glass plate P_1.With lens paper. Keep the glass plate on a black paper laid on the platform of the traveling microscope. Place the convex lens of large radius of curvature on the glass plate with its spherical surface in contact with the glass plate. Direct a parallel beam of light from a sodium lamp on to a thin glass plate P_2 kept inclined at 45^o to the horizontal as shown in fig. The beam of light is reflected on to the lens by the glass plate P_2. As a result of interference between the light rays reflected from the lower surface of the convex lens and the top surface of the thick glass plate P_1, a concentric ring system (Newton's rings) with alternate dark and bright rings having a black spot at the center, will be seen through the microscope. In other words the light reflected from the top and bottom surfaces of the air film superimpose giving rise to interface fringes in the form of alternate bright and dark concentric rings, called Newton's rings.

Ray Diagram

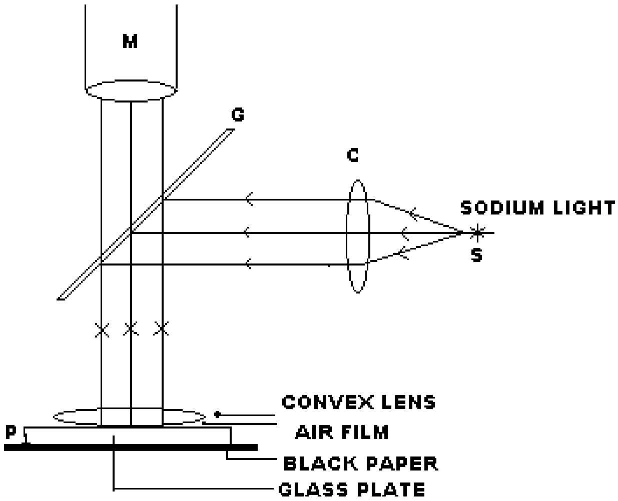


Fig: Experimental arrangement to observe Newton's Rings

Adjust the microscope until the rings are in sharp focus. Improve the definition of the rings by slightly adjusting the reflecting glass plate P_2 with respect to the sodium light. Sometimes due to the presence of the dust particles between the lens and the thick glass plate the central spot may be bright. In such a case clean the surface of the lens and glass plate to get a dark spot at the center.

PROCEDURE:
Determine the least count of the traveling microscope and record it in your observation book. Scribble with pen on a piece of white paper and place it on the glass plate and focus the microscope such that the writing on the white paper is clearly visible. Bring the point of intersection of the cross-wire to the center of the ring system and if necessary turn the cross-wires such that one of them is perpendicular to the line of travel of the microscope. This wire can be set tangential to any ring while making measurement. Starting from the center of the ring system move the microscope, say to the left across the field of view counting the numbers of the rings.

After passing beyond the 20^{th} dark ring tangential to it, note the main scale reading and vernier coincidence on the horizontal scale using a reading lens. Similarly note the readings with the cross wire set successively on the 20^{th}, 18^{th}, 16th, 14th… up to 20^{th} dark ring on the right side. Readings should be taken with the microscope moving in the same direction to avoid errors due to back-slash. Record the observations in the table given below. Note that as the microscope is moved from 20^{th} dark ring on the left to the 20^{th} dark ring on the right the microscope decreases continuously.

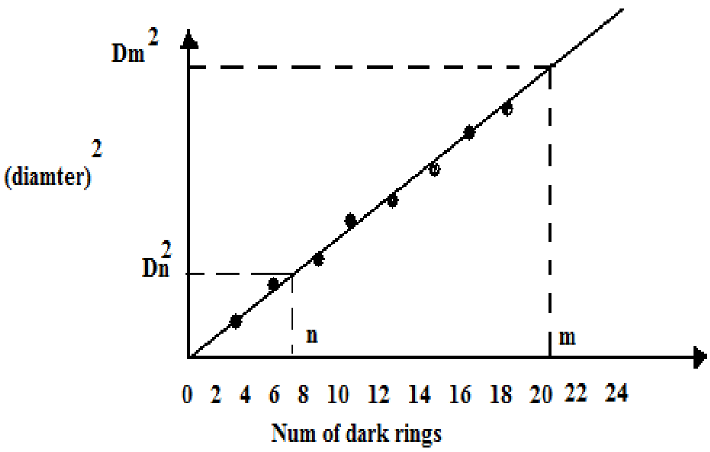
OBSERVATIONS: Least count of the microscope = $\frac{\text{Value of one } M.S.D}{\text{Total Number of vernier scale divisions}}$

TABLE:

No. Of Rings	Microscope Readings						Diameter D= (a ~ b) Cm	(Diameter)^2 D^2 cm^2
	Left			Right				
	MSR Cm	VC	Total M.S.R+ (V.C XL.C) (a) cm	MSR Cm	VC	Total M.S.R+ (V.C XL.C) (b) cm		
20								
18								
16								
14								
12								
10								
8								
6								
4								
2								

Graph:

Draw a graph with number of dark rings on the X-axis and the square of the diameter of the rings on Y-axis. A straight line passing through the origin will be obtained. From the graph ,note down the values of D_m^2 and D_n^2 corresponding to m^{th} (say 5 or 7) by substituting these values in above equation the radius of curvature of the given lens can be found.



Applications:

1.Interference is used in interference Auto Compensators in measurement engineering.

2. Interference is used in CWDM (Coarse Wavelength Division Multiplexing) system, which can have many diverse applications than the existing passive fiber optics.
3. Interference in thin films concept is used in non-reflecting coatings in engineering applications.
4. Laser light optical interference is used in MFM (Magnetic Force Microscopy).

CALCULATIONS: From Graph:

1) m = 13, n =3;

D_m^2 = D_n^2 =

$$R1 = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} cm$$

2) m = 15, n =5;

D_m^2 = D_n^2 =

$$R2 = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} cm$$

3) m = 17, n =7;

D_m^2 = D_n^2 =

$$R3 = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} cm$$

RESULT: Radius of curvature of the given convex lens is R=

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Conclusion: Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PSO1** are attained.

Viva Questions

1. What do you mean by interference of light?
The modification in the distribution of light energy due to the superposition of two or more waves of light is called interference of light.

2. What are the conditions for sustained interference?

(a) The light waves superposing at appoint must have the same wavelength or same frequency.
(b) The amplitude of superposing light waves should be equal or almost equal.
(c) The waves superposing should either have the same phase or constant phase difference.
(d) Light sources must be very narrow and very close to each other.

3. Explain the term coherent sources?
Any two sources of light continuously emitting light waves have zero or constant phase difference are called coherent sources.

4. How Newton's rings are formed?
When a monochromatic light falls normally on Plano convex lens and glass plate set, the light reflected by the lower surface of the lens and the upper surface of the glass plate superpose to produce interference pattern. This circular interference pattern is called Newton's rings.

5. Why the central ring is dark?
The path difference is introduced b/w the two rays as a result of the phase change of $\lambda/2$ for ray reflects from glass plate and no phase change for the ray reflects from plano convex lens. The central ring is dark because the two interfering rays have a path difference (1/2) in spite of the fact that the thickness is zero.

6. How to obtain central bright spot in Newton's rings?
By interpose a film of refractive index less than that of the material of the plate. Then the path difference b/w the two rays becomes central bright spot.

7. On what factors does the diameter of the ring depend?
It depends on the wave length of the light and the radius of the curvature of the plano-convex lens.

8. What are the applications of Newton's rings?
It is used to:
(i) Determine wavelength of unknown light source.
(ii) To determine radius of curvature of given lens.
(iii) Refractive index of the given liquid.

9. Why the center of the rings is dark?
Because the Plano convex lens and the plane glass plate both are in contact and at that particular place the center ring will appear dark.

10. Why the Newton's rings are circular?
The thin air film formed in between the glass plate and the convex lens is having zero thickness at the point of contact of lens and glass plate. Its thickness is symmetrically increasing on both sides of the point of contact. Hence the obtained fringes having dark spot at the center followed by alternate bright and dark circular fringes. These are called Newton's rings. The path difference along the circle is constant that's why the rings are circular in this experiment.

11. What is meant by radius of curvature?
If we extend the curved path of the convex lens to make a sphere, then the radius of such an extended sphere is called Radius of curvature.

Experiment No:
Date:

EXPERIMENT No-3
LASER BEAM DIFFRACTION

AIM: To determine the wavelength of laser beam using n-parallel slits i.e., diffraction grating.

APPARATUS: Laser light source, N-parallel slits (Diffraction grating), Screen and a Meter scale.

FORMULA: The wavelength λ of laser light is given by

$$\lambda = \frac{\text{Sin } \theta}{\text{n N}} A^0$$

Where, θ is the angle of diffraction, **N** is the number of lines per cm on the grating, **n** is the order of the spectrum

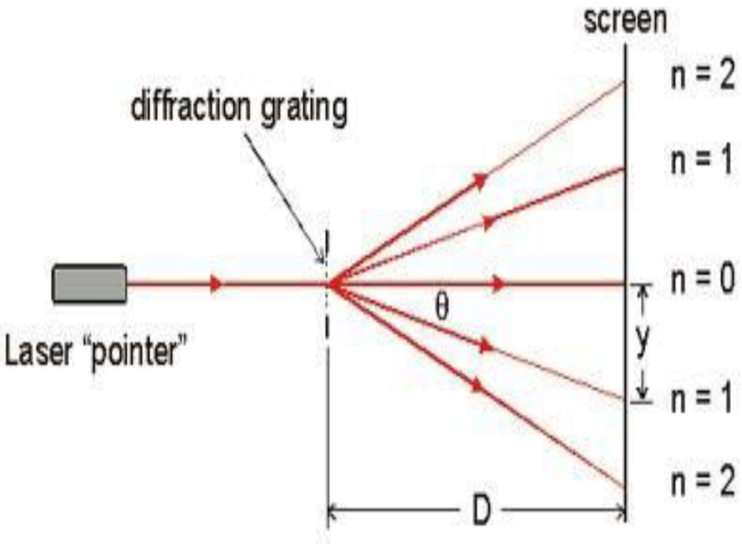
$$\theta = \text{Tan}^{-1} (d/D)$$

Where, λ is the wavelength of laser light, **D** is the distance between the grating (slits) and the screen, **d** is the distance on the screen from the central maximum to the **n**th maximum.

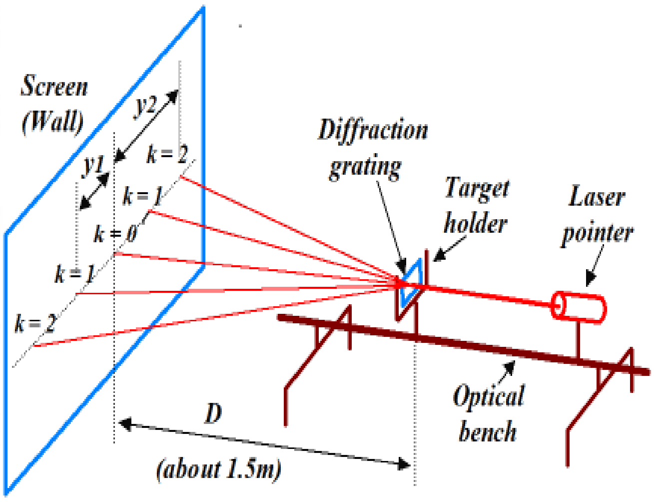
WORKING PRINCIPLE: ***Diffraction of Light:*** Bending of the light rays at the transparent spaces between the equidistant parallel lines on the grating plate is the responsible for diffraction pattern and the grating spectrum.

THEORY:
He-Ne Laser, Ga-As or Semiconductor Laser is generally used as laser source in this experiment. When a laser beam of wavelength λ is allowed to fall on the single slit or diffraction grating placed at a distance D from the screen, the incident laser beam bends at the corners of the slit and produces diffraction pattern on the screen. The diffraction pattern consists of a broad central maximum with narrow secondary maxima and minima on either side of the central maximum as shown in the ray diagram.

Ray Diagram



Experimental Diagram:



PROCEDURE:
Laser source is mounted on a stand. Slit or Diffraction grating is kept at a convenient distance with the lines being vertical at the same height as the source. A screen is placed in front of the slit or grating and the images are formed on the white wall. The distance of the first order image from the direct image is measured on left side as well as right side. The mean of the distance (d) is found. The distance (D) from the grating to the screen is measured (d/D) gives TanΘ. The wavelength of

the light is given by λ = **Sin(Θ)**/Nn   Where N=number of lines per unit length on the grating.   n=order of the spectrum. The experiment is repeated for first and second order spectrums. The readings are tabulated as follows.

Table to determine the wavelength λ of laser light

S.No	Order of the spectrum (**n**)	Distance of screen from the grating **D** (in cm)	Distance of the slit image from direct slit (central maximum) **d** (in cm)			**θ= Tan⁻¹ (d/D)**	**Sinθ**	$\lambda = \frac{\sin\theta}{nN} A^0$
			Left d1	Right d2	Mean d =(d1+d2)/2			
1	1	15						
2	1	20						
3	1	25						
4	1	30						
5	1	35						
6	1	40						
7	1	45						
8	1	50						
9	2	15						
10	2	20						
11	2	25						
12	2	30						
13	2	35						
14	2	40						
15	2	45						
16	2	50						

Applications:

1. Diffraction gratings are used in the production of holograms.
2. Diffraction gratings are used in the laser shows which are popularly used in opening and closing ceremonies of film fare awards, IPL and Olympic games, etc.
3. Spectra produced by diffraction gratings are extremely useful in applications from studying the structure of atoms and molecules to investigating the composition of stars.

PRECAUTIONS:

1. Do not look directly into the laser beam under any circumstance.
2. The source, screen and slit or grating should be at the same height.
3. Readings should be taken without parallax error.
4. Diffraction pattern (minima) should be marked with fine pencil carefully.

RESULT:

The wavelength of the given laser source λ = **A^0**

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Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO5, PO6, PO9 & PO12** and Program specific outcome **PSO1** are attained

Experiment No:
Date:

EXPERIMENT NO – 4
DIFRACTION GRATING

AIM: To determine the wavelength of prominent lines of mercury spectrum by plane diffraction grating in normal incidence position.

APPARATUS: Spectrometer, Mercury lamp, Spirit level, diffraction grating and reading lens.

WORKING PRINCIPLE: ***Diffraction of Light:*** Bending of the light rays at the transparent spaces between the equidistant parallel lines on the grating plate is the responsible for diffraction pattern and the grating spectrum.

FORMULA: If N is the number of lines per cm of the grating, then the width of the slit d=1/N. When light is incident normally on plane grating and if θ is the angle that the diffracted ray makes with the normal then the path difference between two rays passing through successive slits is 'd sinθ' for maximum of the diffracted beam **d sinθ = nλ.**

Therefore the wavelength λ of light incident normally on the grating is

$$\lambda = \frac{\text{Sin } \theta}{\text{n N}} A^0$$

Where,

θ is the angle of diffraction,

N is the number of lines per cm on the grating **(15000 LPI = 5905.511 lines/cm)**

n is the order of the spectrum

PROCEDURE:

i. Find the least count of the spectrometer:

Least count = Value of one M.S.D / No of Vernier scale divisions.

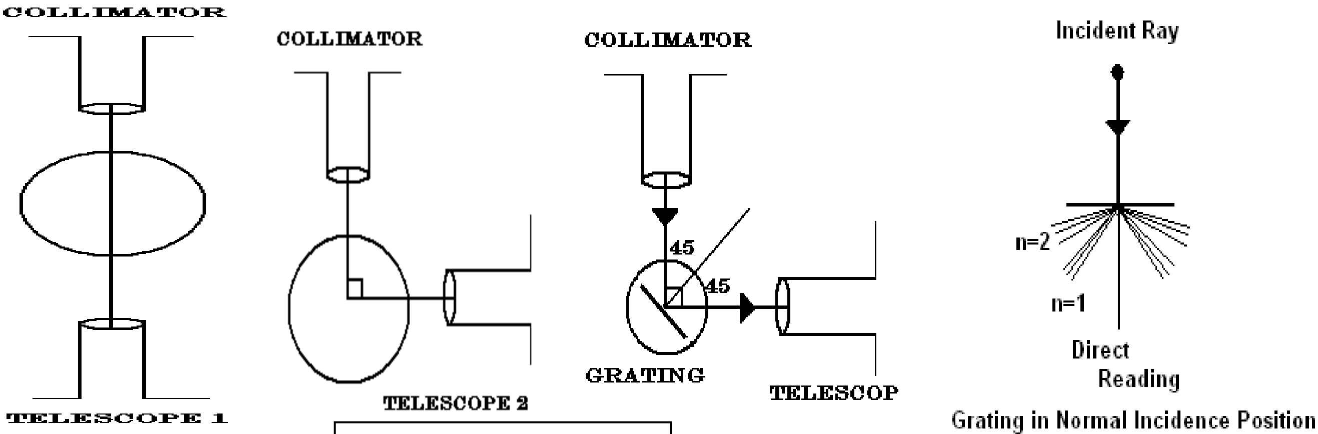
ii. Preliminary adjustments of the spectrometer:

Turn the telescope towards a white surface. Move the eye-piece in or out until the cross wires are seen distinctly. Now focus the telescope to a distant object and by the turning the pinion screw adjusts the distance of the eye-piece from the object until the distant object is clearly seen in the plane of the cross-wires. Now the telescope is adjusted to receive the parallel rays.

The slit of the collimator is illuminated with mercury light and the telescope is brought in line with the collimator. Set the slit of the collimator vertical. Observing through the telescope, the width of the slit and the distance of the slit from the collimator lens are adjusted until a clear image of the slit with well-defined edges is formed in the plane of the cross-wires.

iii. To set the grating in normal incidence position:

Turn the telescope exactly in line with the collimator and observe the image of the slit. Clamp the Vernier table to the prism table. Adjust the position of the telescope so that the vertical cross-wire exactly coincides with the image of the slit and note down the direct reading on both the vernier (Fig 1).Release the telescope and rotate it exactly through 90^o from the direct reading position and fix it. At this position the axis of the collimator and telescope are perpendicular to each other (Fig 2).



Ray Diagram

Mount the grating on the prism table such that the ruled surfaces the collimator. Then release the prism table and looking through the telescope. Rotate the prism table slowly until the reflected image of the slit from the grating exactly coincides with the vertical cross-wire. Keeping the prism table and telescope fixed, release the Vernier table and rotate it exactly though 45° towards the collimator such that the ruled surface of the grating is towards the collimator. Release the telescope and bring it in line with the collimator .Now the grating is said to be in normal incidence position and the light rays from the collimator will be incident on the grating surface perpendicularly. (Fig 3)

iv. Diffracted lines of mercury spectrum:

Now turn the telescope to each the diffracted spectral lines of the mercury spectrum on one side, say to the left. Starting from the extreme left coincide the vertical cross-wire with yellow-2 and note the reading. Similarly note the readings for all lines on the right side of the direct position (Fig 3).The difference between the readings corresponding to any line on left side (L) and right side (R) gives twice the angle of diffraction(2θ) for that line. Half the difference in the readings corresponding to any line gives the angle of diffraction (θ) for that line in the first order spectrum. Tabulate your results as shown in table.

Ray Diagram

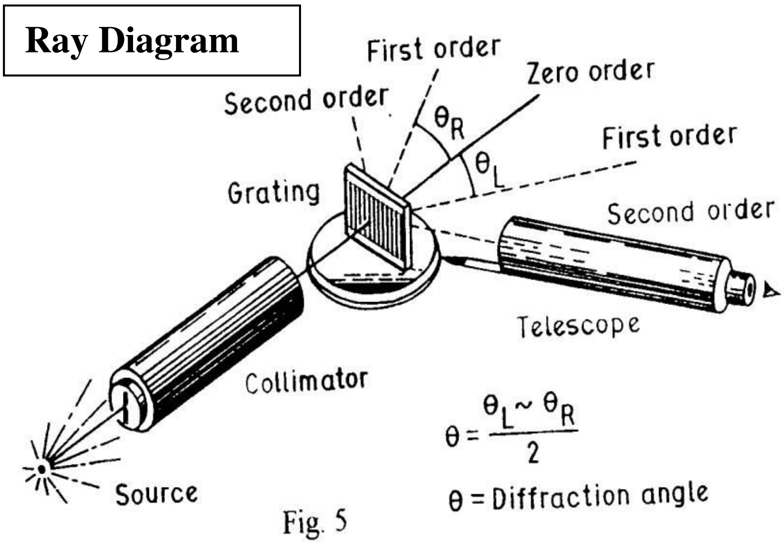


Fig. 5

OBSERVATIONS:

Note down the number of lines per inch marked on the grating and calculate the number of lines N per cm by using the formula

No. of lines per inch/2.54 (N) = 15000 / 2.54 = lines/cm

Order of the spectrum (n) =

L.C of the spectrometer = Value of one M.S.D /total No of Vernier scale divisions

=

Order of the spectrum (n)	Colour of the line	Telescope Reading						Angle of Diffraction θ = (L ~ R)/ 2	$\lambda = \frac{\text{Sin } \theta}{\text{n N}} A^0$
		Left (L)			Right (R)				
		MSR	VC	Total Reading= MSR+(VC X LC) (L)	MSR	VC	Total Reading= MSR+(VC X LC) (R)		
1	Violet								
1	Blue								
1	Bluish Green								
1	Green								
1	Yellow								
1	Red								

CALCULATIONS:

$$\lambda v = \frac{\text{Sin } \theta v}{\text{n N}} A^0 =$$

$$\lambda b = \frac{\text{Sin } \theta b}{\text{n N}} A^0 =$$

$$\lambda bg = \frac{\text{Sin } \theta bg}{\text{n N}} A^0 =$$

$$\lambda g = \frac{\text{Sin } \theta g}{\text{n N}} A^0 =$$

$$\lambda y = \frac{\text{Sin } \theta y}{\text{n N}} A^0 =$$

$$\lambda r = \frac{\text{Sin } \theta r}{\text{n N}} A^0 =$$

Applications:

1. Diffraction of light plays a dominant role in limiting the resolving power of cameras, binoculars, telescopes, microscopes and the eyes.

2. Diffraction gratings are used in the production of holograms.
3. Diffraction gratings are used in the laser shows which are popularly used in opening and closing ceremonies of film fare awards, IPL and Olympic games, etc.
4. Spectra produced by diffraction gratings are extremely useful in applications from studying the structure of atoms and molecules to investigating the composition of stars.
5. Diffraction grating is an immensely useful tool for the separation of the spectral lines associated with atomic transitions
6. Diffraction grating leads to application for measuring atomic spectra in both laboratory instruments and telescopes.
7. The hologram on a credit card and the closely spaced tracks of a CD or DVD act as a diffraction grating for producing a separation of the colors of white light.
8. Diffraction grating is used in ICPAES (Inductively Coupled Plasma Auger Electron Spectroscopy).

RESULT: The wavelengths of prominent lines in the mercury spectrum are determined by using diffraction grating in normal incidence position.

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Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PSO1** are attained

Viva Questions

1. **What is diffraction grating?**
   A plate of glass or metal ruled with very close parallel lines, producing a spectrum by diffraction grating and interference of light.
2. **What are the essential parts of the spectrometer?**
   The essential parts of the spectrometer are Eye-piece, telescope, objective lens, prism table, collimator, slit.
3. **How many types of spectra are available?**
   The familiar spectrum colors are easy to remember with the mnemonic "VIBGYOR" for Red, Orange, Yellow, Green, Blue, Indigo, and Violet. Different light sources have different amounts of these colors.
4. **What is dispersive power of grating?**
   Dispersive power is defined as the rate of change of angle of diffraction with the change of wavelength in a particular order of spectrum.
5. **Define grating element?**
   The distance b/w two adjacent slits is known as granting element/its value is obtained by dividing the length of grating by total number of lines ruled on the grating.
   $d=L/N$; L=length of the grating; N=number of lines ruled on the grating
6. **What is plane transmission diffraction grating?**
   A plane transmission diffraction grating is an optically plane parallel glass plate on which equidistant, extremely close grooves are made by ruling with a diamond point.
7. **In our experiment, what class of diffraction occur and how?**
   Fraunhoffer class of diffraction occurs. Since the spectrometer is focused for parallel rays, the source and the image are effectively at infinite distances from the grating.
8. **What type of diffraction occurs in this experiment?**
   Fraunhoffer diffraction
9. **What are maximum numbers of possible orders with the given grating?**
   Three (n=3).
10. **Among the three possible orders which order you are observing?**
    First order (n=1)

Experiment No:
Date:

EXPERIMENT NO – 5

ENERGY GAP OF THE SEMICONDUCTOR

Aim

To determine the energy band gap of the given semiconductor using p-n junction diode.

Apparatus

Semiconductor diode, dc power supply, Thermometer, Oven, Ammeter and Voltmeter.

Introduction

A semiconducting material is comprised of valence band and conduction band separated by a narrow energy difference of nearly 1eV. The conduction band is almost empty while the valence band is nearly full. This narrow energy gap is called as the forbidden energy gap or the energy band gap. There are two types of semiconductors. They are intrinsic (or) pure semiconductors and extrinsic (or) impure semiconductors. The electrical conductivity of a pure semiconductor can be drastically varied by addition of minute impurities. Extrinsic semiconductors are formed by adding impurity (doping) to pure semiconductors. The n-type semiconductor is formed by doping trivalent impurity (e.g. Ga^{3+}) to pure semiconductor while the p-type semiconductor is formed by doping a pentavalent impurity (As^{5+}). The p-type semiconductors are electron deficient while the n-type are excess in electrons.

WORKING PRINCIPLE:

The electrical conductivity of a germanium or silicon test piece is measured as a function of temperature. The energy gap is determined from the measured values.

FORMULAE:

The temperature dependence of reverse saturation current I_S in p-n junction diode is given by,

$$I_S = A\ e^{\frac{-E_g}{\eta KT}} \qquad (1)$$

where, A is the constant, E_g is the band energy gap of the semiconductor in eV, K in Boltzmann constant in 8.625 × 10^{-5} eV/K, T is the absolute temperature and η =1 for Ge and η = 2 for Si.

for instance in case of Ge,

$$I_S = A\ e^{\frac{-E_g}{KT}} \qquad (2)$$

On taking logarithm to base 10 on both sides, we get,

$$\log I_S = \log A - 0.4303\ (\frac{E_g}{KT})$$

$$\log I_S = \log_{10} A - 5036\ (\frac{E_g}{T}) \qquad (3)$$

In the operating range of diodes, the temperature dependence of I_S is mainly determined by the second term of Eq. (3) even though A is temperature dependent.

Hence, a graph with $\frac{1}{T}$ on x-axis T in K and $\log_{10} I_S$ on Y-axis will be a straight line having a slope of magnitude m = 5.036 × E_g. From this the energy band gap of the p-n junction diode is calculated to be

$$E_g = |m|/5.036 \text{ eV} \qquad (4)$$

Where m-slope of the straight line from graph

Description: The arrow head of p-n junction diode 'D' represents the anode (of p region) and the vertical line represents the cathode (n region). As shown in figure (1). When diode is reverse biased i.e. p-region is connected to negative terminal of the battery and n-region is connected via the ammeter to the positive terminal of battery, the current flowing through the diode is negligibly small in rage of µA and is called as reverse saturation current.

Circuit Diagram:

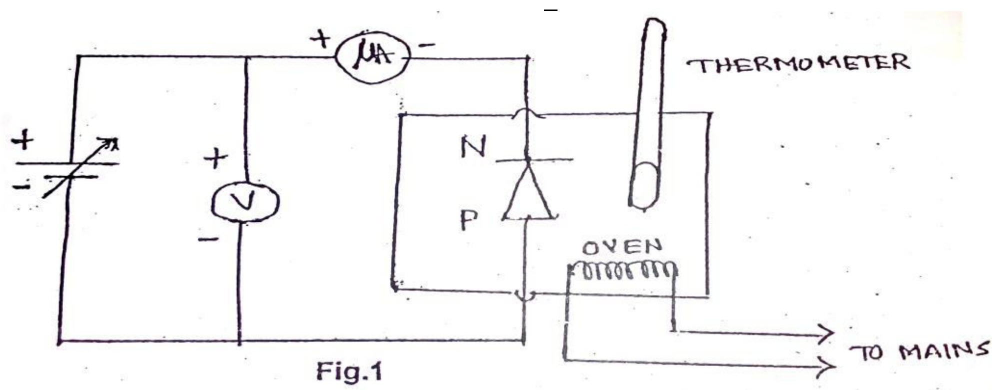
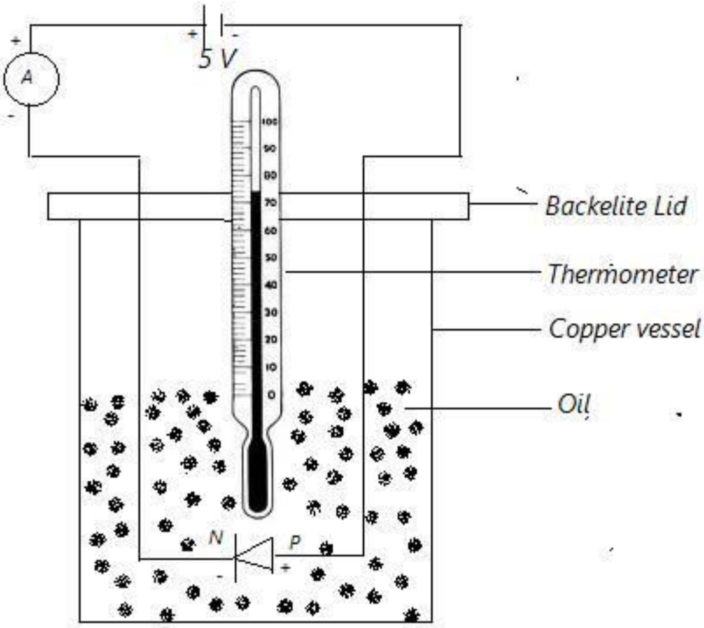


Fig.1

Experimental Diagram:



In our experiment we study the effect of temperature on the reverse saturation current in the diode and there from estimate the energy band gap of the semiconductor material.

Procedure

The connections are made as shown in the figure (1). A small reverse bias voltage is applied across the diode by adjusting the potentiometer 'P'. The applied voltage is recorded using a voltmeter and the corresponding reverse saturation current (I_S) is noted using a micro-ammeter.

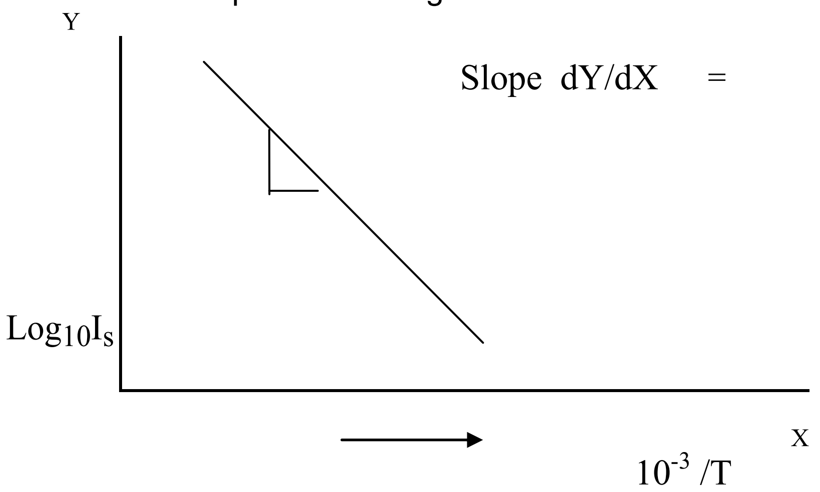
The reverse bias voltage is maintained constant throughout the experiment. During heating cycle, the oven is switched on and the temperature of the diode increases slowly. Now, the reverse saturation current values ($(I_S)_{increase}$) are noted together with the corresponding temperatures in
Conversely in the cooling cycle, the oven is switched off and system is cooled. Now, the reverse saturation current values ($(I_S)_{decrease}$) corresponding to the temperature range of 70°C to 30°C are tabulated in steps of 5°C respectively.
At any temperature, the average value of reverse saturation current will be considered. $I_S = ((I_S)_{increase} + (I_S)_{decrease})$ **/ 2.**

Readings are tabulated in the table and graph is between $\frac{1}{T} \times 10^3$ on x- axis T in K and $\log_{10} I_S$ on Y- axis is drawn and slope is found and E_g is calculated.

Observations:

S.No	Temperature		Reverse Saturation Current (I) in μA			Log_{10} (I_s)	1/TX10^{-3} K^{-1}
	Temp in t ^{0}C	Temp T (K)	Current(I_H) Heating	Current (I_C) Cooling	$I_S = (I_H + I_C)/2$		
1	30^0						
2	35^0						
3	40^0						
4	45^0						
5	50^0						
6	55^0						
7	60^0						
8	65^0						
9	70^0						
10	75^0						

Graph: Draw the graph between 1/T versus log (I_s), straight line passing through positive 'X' axis. Find mod of the slope of the straight line



CALCULATIONS:

From graph slope of the line dy/dx =

E_g = slope/ 5.04 = ____________ eV

Standard value for Ge = 0.72 eV; Standard value for Si = 1.1 eV

Precautions:

1. Do not operate above 90°C.
2. Temperatures are to be determined accurately.
3. Observations should be taken not only as the temperature rise but also when it cools.
4. The current flow should not be too high, if the current is high then the internal heating of the device will occur. This will cause actual temperature of the junction to be higher then the measured value. This will produce non-linearity in the curve.

Result: The Energy band gap of semiconductor is $\mathbf{E_g}$ = --------------- eV.

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Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PSO1** are attained.

VIVA QUESTIONS

1. **What is a p-type semiconductor?**
   Semiconductor formed by adding trivalent impurities in which the majority carriers are holes is called as a p-type semiconductor
2. **What is an n-type semiconductor?**
   Semiconductor formed by adding pentavalent impurities in which the majority carriers are electrons are called as a n-type semiconductor.
3. **What is doping?**
   The process of changing the performance of a semiconductor by introducing a small number of suitable replacement atoms as impurities into the semiconductor lattice is called as doping.
4. **Due to what phenomenon does the reverse saturation current arise?**
   The reverse saturation current arise in a junction diode due to the diffusion of minority charge carriers.(Electrons in p-region & holes in n-region are respective minority charge carriers.)
5. **Why does the reverse saturation current depend on temperature?**
   This is because the reverse saturation current is due to diffusion of minority charge carriers which are thermally generated. The diffusion is also temperature dependent. Hence the reverse saturation current is highly sensitive to temperature.

7. **What is diffusion?**
   The motion of charge carriers takes place when there is a non uniform distribution of charged particles. This process is called as diffusion.
8. **Why reverse bias current is called as reverse saturation current?**
   Because the reverse current becomes saturated quickly with the increase in the reverse bias.
9. **What are the values of band gap for metals, semiconductors and insulators?**
   For metals= 0eV, Semiconductors= 0.5 -3 eV and for insulators greater than 3 eV.
10. **Which type of semiconductor is used in the given apparatus?**
    Germanium (Ge)
11. **Which type of transformer is used in this experiment and what is it?**
    Step down transformer. It is a device, which converts high voltage currents to low voltage currents.

EXPERIMENT No - 6

WEDGE METHOD

Experiment No:
Date:

AIM: To measure the diameter of a given thin wire (*or* thickness of given thin paper) using interference patterns formed by an extended source, at the air wedge between two glass plates.

Apparatus: Glass plate, thin wire, beam splitter, light source, traveling microscope etc.

Working Principle: ***Interference of Light:*** The light reflected from the upper and lower surfaces of thin air film formed in between the lower surface of top glass plate and upper surface of the bottom glass plate.

Formula: The Thickness of the glass plate is

$$t = \lambda\, l / 2\beta$$

Where t is thickness of the glass plate

β is the mean fringe width

l is the distance between the inner edge of the paper (or hair) & the point of contact of glass plates in cm.

Theory:

Interference effects are observed in a region of space where two or more coherent waves are superimposed. Depending on the phase difference, the effect of superposition is to produce variation in intensities which vary from a maximum of $(a_1 + a_2)^2$ to a minimum of $(a_1 - a_2)^2$ where a_1 and a_2 are amplitude of individual waves. For the interference effects to be observed, the two waves should be coherent. Interference patterns can be observed due to reflected waves from the top and bottom surfaces of a thin film medium. Because of the extended source, the fringes are localized at or near the wedge.

Ray Diagram

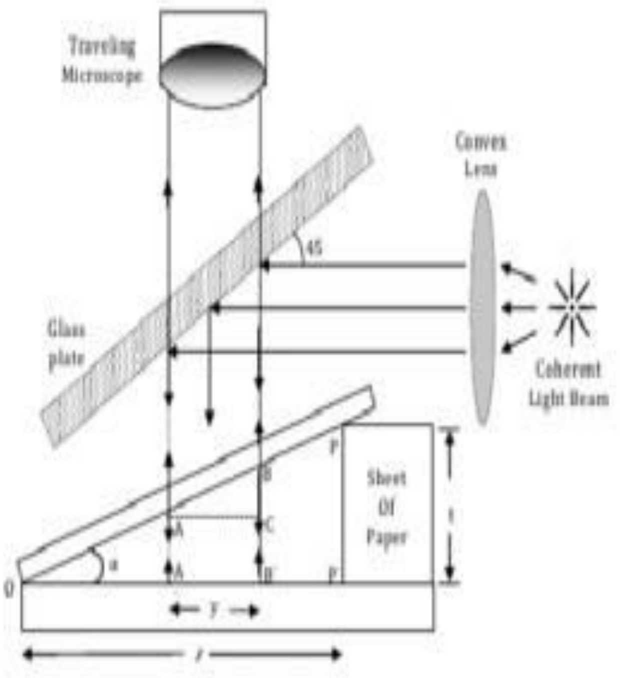


Fig. Shows the cross sectional view of the two flat glass plates kept on each other and separated by a wire at the rightmost end. There is a thin air film between the two glass plates due to the paper kept at the right end.

The path difference between the two ray's r_1 and r_2 is $2t \cos r$, where't' is the air thickness as shown in the figure.

The condition for dark band is,

$$2t\cos r = m\lambda$$

If the incident ray is close to normal, $2t = m\lambda$ ………………(1)

For m = N, the maximum order of the dark band the path difference will be maximum and this correspond to the position where the wire is kept . Moreover, here the fringes are equal thickness fringes. So eqn (1) can be written as

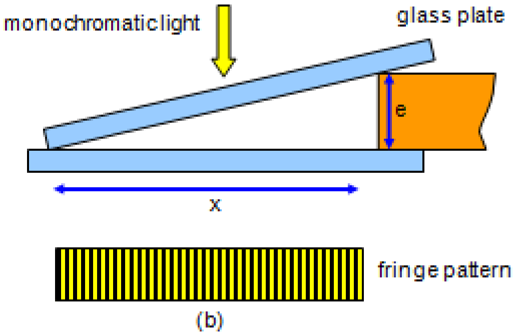
$$2d = N\lambda \text{ .... (2)}$$

The length 'l' shown in the figure can be written as

$$l = N\beta \text{ .... (3)}$$

where β is the fringe width. From eq (2) and (3),

$$\mathbf{t = \lambda l/2\beta} \text{ --------------------------(4)}$$



Procedure:

- Place the two optically flat glass plates one over the other, so that they touch each other at the left end and are separated at the right end by the given thin wire. The length of the wire should be perpendicular to the length of the glass plate.
- Place this assembly on the platform of the microscope such that the length of the glass plate is parallel to the horizontal traverse of the microscope.
- Illuminate the assembly by sodium light. Adjust the glass plate G, such that incident light is almost normal to the glass plate wire assembly.
- Focus the microscope to observe the interference patterns
- Measure the horizontal positions of the dark bands in the order of say, m, m+5, m+10,......... by traversing the microscope horizontally.
- Determine the length 'L' with the help of microscope.
- Plot a graph of horizontal positions versus order of dark band. Find out the mean fringe width β from the table and calculate the thickness of the given wire.

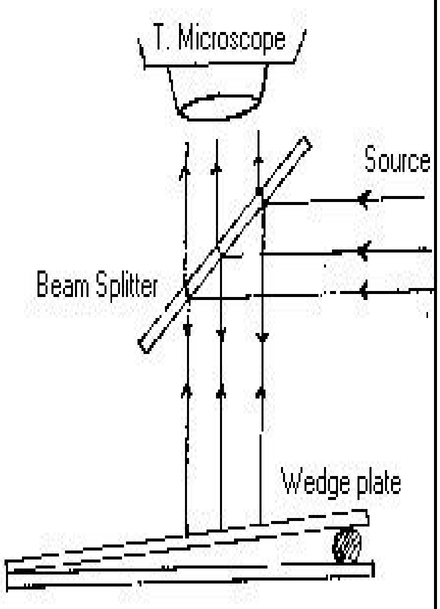
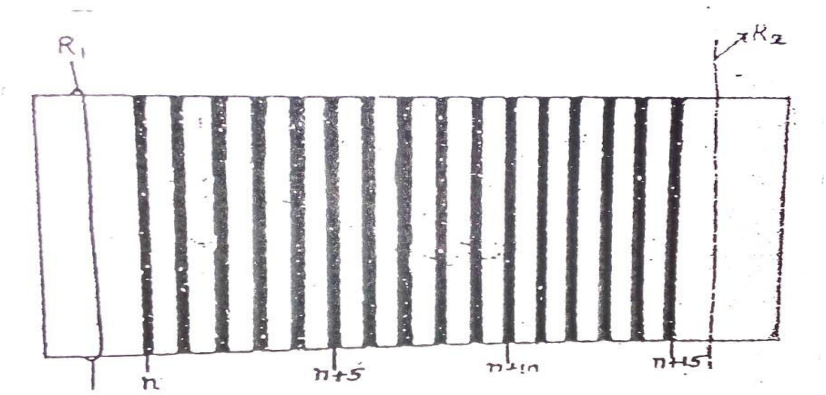


Fig. 2 Experimental setup



Formation of alternate bright and dark fringes

Observations:

To determine fringe width β:

S.No.	Order of Fringe	M.S.R. (a) cm	V.C (n)	Total reading = a + nx L.c	Width of 5 fringes cm	Width of one fringe Cm
1	0^{th}				-----	-----
2	5^{th}					
3	10^{th}					
4	15^{th}					
5	20^{th}					
6	25^{th}					
7	30^{th}					
8	35^{th}					
9	40^{th}					
10	45^{th}					
11	50^{th}					
12	55^{th}					
13	60^{th}					

To determine the length of the air wedge (l):

Microscope readings						
At the point of contact of the two glass plates			At the position of hair or paper			$l = R_1 \sim R_2$
M.S.R a cm	V.C N	R_1= a+ nxL.C Cm	M.S.R a cm	V.C N	R_2= a+ nxL.C cm	

Calculations:

Precautions:

1. While using microscope to measure fringe width etc., it is moved in one direction only from left to right or right to left, so that back lash error is avoided.
2. To achieve good accuracy in the measurements of beta and l, measurements are repeated thrice.

Applications:

1. Because of its extremely thin air-gap, the air-wedge interferometer was successfully applied in experiments with femto-second high-power lasers.
2. The air-wedge shearing interferometer is similar to the classical shearing interferometer but is micrometers thick, can operate with virtually any light source even with non-coherent white light, has an adjustable angular beam split, and uses standard inexpensive optical elements.

3. Design described in this article eliminates this obstruction and makes the air-wedge interferometer effective for practical applications with a visualization field interferometer
4. The air-wedge interferogram from even this very short coherence length laser beam exhibits clear, high-contrast interference lines.

Result: Thickness of the given thin paper (or wire) t = … … … … … …cm.

Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PSO1** are attained.

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Viva Questions

1. Is there is any energy loss in interference phenomenon?
No, there is only redistribution of energy i.e., energy from dark places is shifted to bright places.

2. What are interference fringes?
They are alternately bright and dark patches of light obtained in the region of superposition of two wave trains of light.

3. What is the shape of the fringes in wedge shaped film?
The fringes in wedge shaped film are straight line fringes.

4. What type of source is required in division of amplitude?
In division of amplitude a board source is required so that the whole firm may be viewed together.

5. Define air wedge?
Wedge shaped (V shaped) air film is formed between two plane surfaces inclined at small angle. When the film is illuminated by monochromatic light, alternate dark and bright fringes lines equidistant from one another is formed parallel to the thin edge of the wedge are obtained.

6. What is meant by fringe width?
Fringe width is defined as the separation b/w two consecutive maxima or minima.

7. What is meant by maxima and minima?
MAXIMA: The positions of maximum intensity are called maxima.
MINIMA: The positions of minimum intensity are called minima.

8. What is monochromatic wavelength of light?
The light having only one wavelength is called monochromatic wavelength of light.

9. What is wave length?
Wavelength is defined as the distance b/w any two points with the same phase, such as b/w crests, or troughs, or corresponding zero crossings as shown.

10. On which factor, the contrast in fringes in interference pattern depends?
The contrast in fringes in any interference pattern depends on intensity ratio of source.

11. What is locus of fringe?
A fringe is a locus of constant phase.

12. What is the use of intersecting 45^0 angled glass plate?
The use of intersecting 45^0 angled glass plate is important so the light will be split up into two components. ie reflected from the plate is normal (or) right angled (90^0)

EXPERIMENT No-7

NUMERICAL APERTURE & ACCEPTANCE ANGLE

AIM:

To determine the numerical aperture and the acceptance angle of the optical fiber.

APPARATUS:

Optical Fiber Trainer set, NA measuring Jig, one meter & three meter Optical fiber Cables, Mandrel and in-line SMA adaptor.

FORMULAE: $NA = W/ (4L^2 + W^2)^{1/2}$ & $\theta = Sin^{-1} (NA)$

Where NA is the Numerical Aperture of the fiber, L is the distance of the screen from the fiber end, W is the diameter of the spot and θ is the acceptance angle of the fiber.

WORKING PRINCIPLE: ***Total Internal Reflection:-*** "When a ray of light traveling in a medium of higher refractive index n_1 strikes a second medium of lower refractive index n_2 with an angle of incidence $\mathbf{i > \theta_c}$ (Critical angle $\mathbf{\theta_c = n_2/n_1}$) then the ray is totally reflected into the same medium". This phenomenon is called *Total Internal Reflection.*

THEORY:

Numerical aperture of any optical system is a measure of how much light can be collected by the optical system. It is the product of the refractive index of the incident medium and the sine of the maximum ray angle.

$NA = n_i.\sin\theta_{max}$, n_i for air is 1, hence $NA = \sin\theta_{max}$

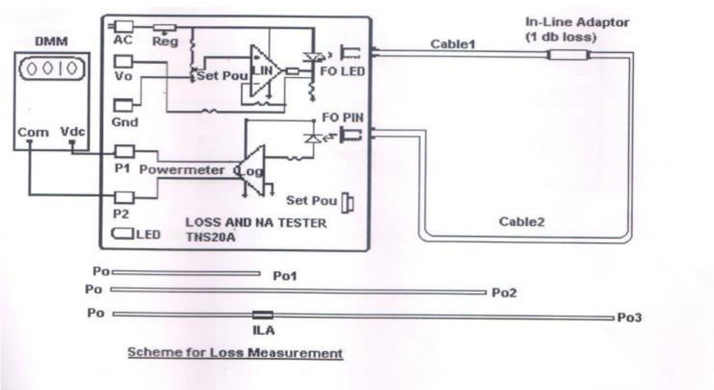
The numerical aperture is given by $NA = (n_1^2 - n_2^2)^{1/2}$

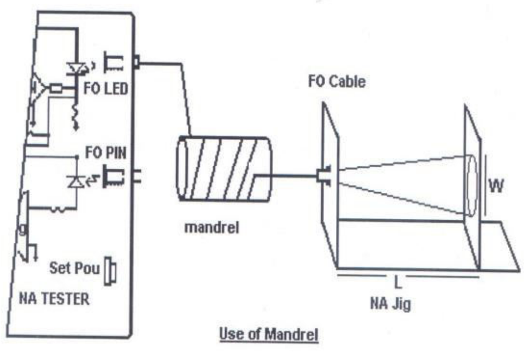
For a step-index fiber, as in the present case, the numerical aperture is given by

NA =, where Δ is the fractional difference in refractive indices,

The experimenter may refer to the specifications of the optical fiber given in Appendix and record the manufacture's NA, n_1, n_2 and θ.

Circuit Diagram:





PROCEDURE:

The schematic diagram of the numerical aperture measurement system is shown in Figure and is self explanatory.

Step 1: Connect one end of the Cable 1 (1-metre FO cable) to FO LED of TNS20A and the other end to the NA Jig, as shown.

Step 2: Plug the AC mains. Light should appear at the end of the fiber on the NA Jig, Turn the Set Pout knob clock wise to set to maximum Po. The light intensity should increase.

Step 3: Hold the white screen with the concentric circles (10, 15, 20 and 25 mm diameter) vertically at a suitable distance to make the red spot from the emitting fiber coincide with the 10mm circle. Note that the spot (outermost) must coincide a with the circle. A dark room will facilitate good contrast. Record L, the distance of the screen from the fiber end and note the diameter (W) of the spot. You may measure the diameter of the circle accurately with a suitable scale.

Step 4: Compute NA using the above formula. Tabulate the reading and repeat the experiment for 15mm, 20mm and 25mm diameters too.

Step 5: In case the fiber is under filled, the intensity within the spot may not be evenly distributed. To ensure even distribution of light in the fiber, first remove twists on the fiber and then wind 5 turns of the fiber on to the mandrel as shown. Use an adhesive tape to hold the windings in position. Now view the spot. The intensity will be more evenly distributed within the core.

TABLE:

S.No	Distance b/n the fiber end & the screen L (mm)	Diameter of the spot W (mm)	Numerical Aperture (NA)	Acceptance angle (θ) in degrees
1				
2				
3				
4				
5				
6				
7				

PRECAUTIONS:

1. Take the readings without parallax error.
2. Fiber should be free from all the twists & bendings.
3. The circumference of the spot must coincide with the circle on the NA measuring Jig.

APPLICATIONS:

1. These are used in hospitals in the treatment of eyes surgery, Laparoscopic surgery, angioplasty etc.
2. These are used in defense like army, navy, airplane applications.

3. These are used as sensors in satellite communication system.

4. These are used in many communication systems such as TV, Internet & telecommunication etc.

RESULT:

The numerical aperture of the optical fiber NA =

The acceptance angle of the fiber **θ =**

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Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO5, PO6, PO9 & PO12** and Program specific outcome **PSO1** are attained.

VIVA QUESTIONS

1) **What is meant by an optical Fiber?**
An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.

2) **What is the principle of an optical Fiber?**
The principle of an optical fiber is Total Internal Reflection.

3) **What is meant by Total Internal Reflection?**
When a ray of light traveling in a medium of higher refractive index n_1 strikes a second Medium of lower refractive index n_2 with an angle of incidence **$i > \theta_c$** (Critical angle **$\theta_c = n_2/n_1$**) then the ray is totally reflected into the same medium". This phenomenon is called Total Internal Reflection.

4) **What is meant by Numerical Aperture of an optical Fiber?**
Numerical aperture is thus considered as a light gathering capacity of an optical fibre. Numerical Aperture is defined as the Sine of half of the angle of fiber's light acceptance cone.

5) **What is meant by Acceptance angle of an optical Fiber?**
The acceptance angle of an optical fiber is defined based on a purely geometrical consideration (ray optics): it is the maximum angle of a ray (against the fiber axis) hitting the fiber core which allows the incident light to be guided by the core.

6) **What is meant by Fiber-optic communication?**
Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber.

7) **What is meant by transmission loss or Attenuation in optical fiber?**
Attenuation in fiber optics, also known as transmission loss, is the reduction in intensity of the light beam (or signal) as it travels through the transmission medium.

EXPERIMENT No - 8

RESOLVING POWER OF GRATING

AIM: To determine the resolving power of diffraction grating by mercury spectrum in normal incidence position.

APPARATUS: Spectrometer, Mercury lamp, Spirit level, Plane diffraction grating and reading lens.

WORKING PRINCIPLE: ***Diffraction of Light:*** Bending of the light rays at the transparent spaces between the equidistant parallel lines on the grating plate is the responsible for diffraction pattern and the grating spectrum.

FORMULA: If N is the number of lines per cm of the grating, then the width of the slit d=1/N. When light is incident normally on plane grating and if θ is the angle that the diffracted ray makes with the normal then the path difference between two rays passing through successive slits is 'd sinθ' for maximum of the diffracted beam **d sinθ = nλ.**

Therefore the resolving power of given grating is given by

$$\lambda / d\lambda = nN$$

Where,

λ is the wavelength of the light source

$d\lambda$ is difference in two wavelengths ,

N is the number of lines per cm on the grating **(15000 LPI = 5905.511 lines/cm)**

n is the order of the spectrum

PROCEDURE:

i. Find the least count of the spectrometer:

Least count = Value of one M.S.D / No of Vernier scale divisions.

ii. Preliminary adjustments of the spectrometer:

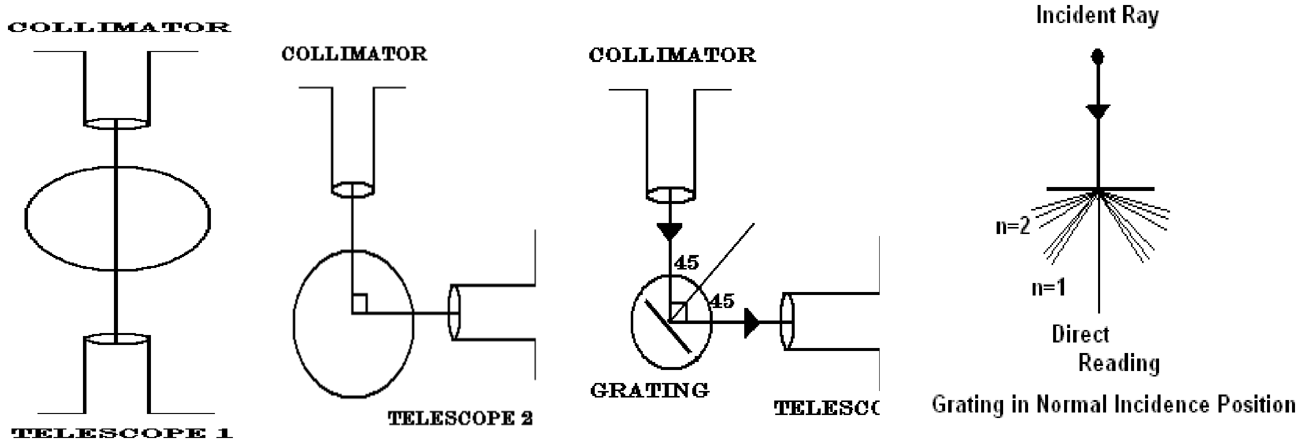
Turn the telescope towards a white surface. Move the eye-piece in or out until the cross wires are seen distinctly. Now focus the telescope to a distant object and by the turning the pinion screw adjusts the distance of the eye-piece from the object until the distant object is clearly seen in the plane of the cross-wires. Now the telescope is adjusted to receive the parallel rays.

The slit of the collimator is illuminated with mercury light and the telescope is brought in line with the collimator. Set the slit of the collimator vertical. Observing through the telescope, the width of the slit and the distance of the slit from the collimator lens are adjusted until a clear image of the slit with well-defined edges is formed in the plane of the cross-wires.

iii. To set the grating in normal incidence position:

Turn the telescope exactly in line with the collimator and observe the image of the slit. Clamp the Vernier table to the prism table. Adjust the position of the telescope so that the vertical cross-wire exactly coincides with the image of the slit and note down the direct reading on both the vernier (Fig 1).Release the telescope and rotate it exactly through 90^{o} from the direct reading position and fix it. At this position the axis of the collimator and telescope are perpendicular to each other (Fig 2).

Ray Diagram



Mount the grating on the prism table such that the ruled surfaces the collimator. Then release the prism table and looking through the telescope. Rotate the prism table slowly until the reflected image of the slit from the grating exactly coincides with the vertical cross-wire. Keeping the prism table and telescope fixed, release the Vernier table and rotate it exactly though 45^{o} towards the collimator such that the ruled surface of the grating is towards the collimator. Release the telescope and bring it in line with the collimator .Now the grating is said to be in normal incidence position and the light rays from the collimator will be incident on the grating surface perpendicularly. (Fig 3)

iv. Diffracted lines of mercury spectrum:

Now turn the telescope to each the diffracted spectral lines of the mercury spectrum on one side, say to the left. Starting from the extreme left coincide the vertical cross-wire with yellow-2 and note the reading. Similarly note the readings for all lines on the right side of the direct position (Fig 3).The difference between the readings corresponding to any line on left side (L) and right side (R) gives twice the angle of diffraction(2θ) for that line. Half the difference in the readings corresponding to any line gives the angle of diffraction (θ) for that line in the first order spectrum. Tabulate your results as shown in table.

Ray Diagram

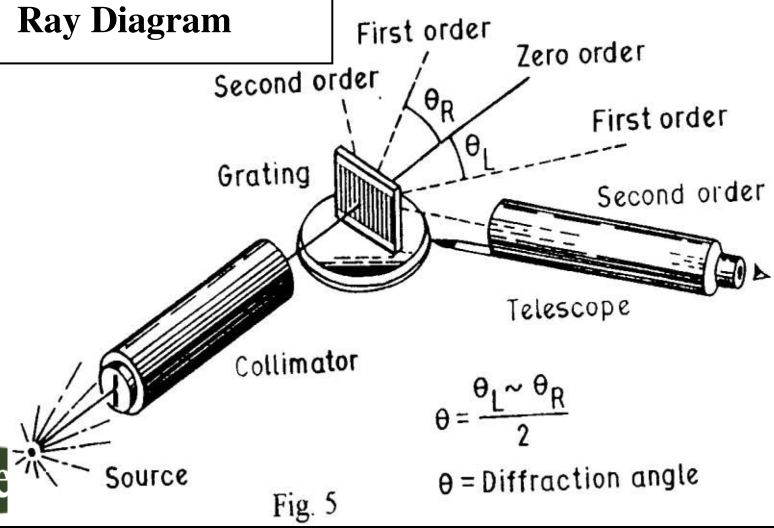


Fig. 5

OBSERVATIONS:

Note down the number of lines per inch marked on the grating and calculate the number of lines N per cm by using the formula

No. of lines per inch/2.54 (N) = 15000 / 2.54 = lines/cm

Order of the spectrum (n) =

L.C of the spectrometer = Value of one M.S.D /total No of Vernier scale divisions

=

Order of the spectrum (n)	Colour of the line	Telescope Reading						Angle of Diffraction θ = (L ~ R)/ 2	$\lambda = \frac{\text{Sin } \theta}{\text{n N}} A^0$
		Left (L)			Right (R)				
		MSR	VC	Total Reading= MSR+(VC X LC) (L)	MSR	VC	Total Reading= MSR+(VC X LC) (R)		
1	Green1								
1	Green2								
1	Yellow1								
1	Yellow2								
1	Red1								
1	Red2								

CALCULATIONS:

For green color n=1

For yellow color n=1

For red color n=1

Applications:

1. Diffraction of light plays a dominant role in limiting the resolving power of cameras, binoculars, telescopes, microscopes and the eyes.
2. Diffraction gratings are used in the production of holograms.
3. Diffraction gratings are used in the laser shows which are popularly used in opening and closing ceremonies of film fare awards, IPL and Olympic games, etc.
4. Spectra produced by diffraction gratings are extremely useful in applications from studying the structure of atoms and molecules to investigating the composition of stars.
5. Diffraction grating is an immensely useful tool for the separation of the spectral lines associated with atomic transitions
6. Diffraction grating leads to application for measuring atomic spectra in both laboratory instruments and telescopes.
7. The hologram on a credit card and the closely spaced tracks of a CD or DVD act as a diffraction grating for producing a separation of the colors of white light.
8. Diffraction grating is used in ICPAES (Inductively Coupled Plasma Auger Electron Spectroscopy).

RESULT: The resolving power of diffraction grating is determined by using diffraction grating in normal incidence position.

Signature of Faculty with date & Remark

Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PSO1** are attained.

Viva Questions

1. **What is diffraction grating?**
   A plate of glass or metal ruled with very close parallel lines, producing a spectrum by diffraction grating and interference of light.
2. **What are the essential parts of the spectrometer?**
   The essential parts of the spectrometer are Eye-piece, telescope, objective lens, prism table, collimator, slit.
3. **How many types of spectra are available?**
   The familiar spectrum colors are easy to remember with the mnemonic "VIBGYOR" for Red, Orange, Yellow, Green, Blue, Indigo, and Violet. Different light sources have different amounts of these colors.
4. **What is dispersive power of grating?**
   Dispersive power is defined as the rate of change of angle of diffraction with the change of wavelength in a particular order of spectrum.
5. **Define grating element?**
   The distance b/w two adjacent slits is known as granting element/its value is obtained by dividing the length of grating by total number of lines ruled on the grating.
   $d=L/N$
   L=length of the grating
   N=number of lines ruled on the grating
6. **What is plane transmission diffraction grating?**
   A plane transmission diffraction grating is an optically plane parallel glass plate on which equidistant, extremely close grooves are made by ruling with a diamond point.
7. **In our experiment, what class of diffraction occur and how?**
   Fraunhoffer class of diffraction occurs. Since the spectrometer is focused for parallel rays, the source and the image are effectively at infinite distances from the grating.
8. **What type of diffraction occurs in this experiment?**
   Fraunhoffer diffraction
9. **What are maximum numbers of possible orders with the given grating?**
   Three (n=3).
10. **Among the three possible orders which order you are observing?**
    First order (n=1)

Experiment No:
Date:

EXPERIMENT No – 9

BREWSTER'S ANGLE DETERMINATION

Aim:

To verify the Brewster's law and to find the Brewster's angle.

Theory & Introduction:

An ordinary light source consists of a very large number of randomly oriented atomic emitters. They radiate polarized wave trains for roughly 10^{-8} s. These wave trains combine to form a single resultant polarized wave which persists for a short time, not more than 10^{-8} s. Since natural light composes of a large number of rapidly varying succession of the different polarization states it is said to be an unpolarised or randomly polarized light.

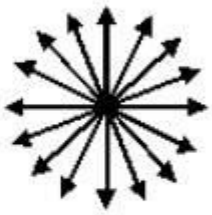


Figure (a)

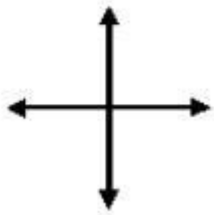


Figure (b)

The natural light can be expressed in terms of two arbitrary, incoherent, orthogonal, linearly polarized waves of equal amplitude. Figure (a) shows randomly polarized natural light and figure (b) shows the splitting at 50% horizontal and 50% vertical states.

A light is said to be a plane polarized light, if all the vibrations are confined to a single plane. Consider an unpolarised light incident on a transparent surface. If the angle of incidence is equal to a particular angle of incidence, the reflected light produced will be completely plane polarized. This particular angle is called the Brewster's angle or the polarizing angle θ_B.

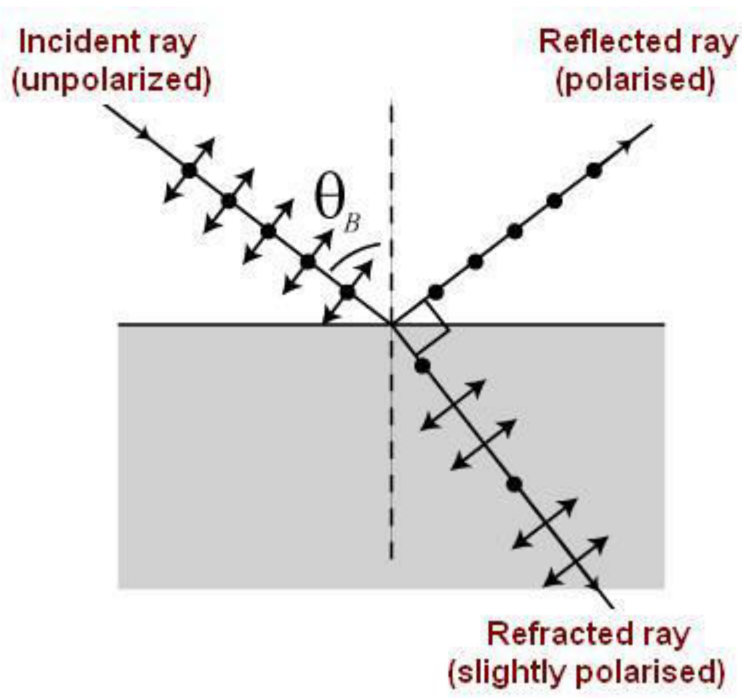
Sir David Brewster, in 1892, found that the maximum polarization of the reflected ray occurs when the reflected ray is perpendicular to the refracted ray. This is called the Brewster's law.

$$r = 90^\circ - \theta_B$$

Brewster's equation:

$$\tan\,\theta_B = \frac{\mu_2}{\mu_1}$$

Where, μ_2 is the refractive index of the reflecting surface and μ_1 is the refractive index of the surrounding medium. The refracted ray so produced will be partially polarized. As the refractive index changes the polarizing angle differs but it is independent of the wavelength of light used.



Procedure for Performing the Simulation:

Drag the components from the right panel and place them correctly in the optic bench.

Start: This button enables the user to start the experiment.

Side view/Top view: Using this, different views of the experimental arrangement can be seen.

Choose light: Using this combo box, one can select different lasers.

Choose medium: The medium of different refractive index can be selected using this combo box.

Choose material: Different materials can be selected using this combo box.

Switch on light: The user can make the laser source ON/OFF using this button.

Angle of the polarizer: Using this slider, one can change the angle of the polarizer from zero to 360 degrees.

Angle of incidence: This slider helps one to change the angle of incidence, which can be varied from zero to 360 degrees.

Observations & Readings:-

S.No	Name of the Medium	Refractive index of medium (μ_1)	Name of the Material	Refractive index of material (μ_2)	Current	Brewster's Angle
1	Air	1	Topaz	1.607		
2	Air	1	Crown Glass	1.52		
3	Air	1	Flint Glass	1.57		
4	Helium	1.00003	Topaz	1.607		
5	Helium	1.00003	Crown Glass	1.52		
6	Helium	1.00003	Flint Glass	1.57		
7	Hydrogen	1.00013	Topaz	1.607		
8	Hydrogen	1.00013	Crown Glass	1.52		
9	Hydrogen	1.00013	Flint Glass	1.57		
10	Carbon dioxide	1.0	Topaz	1.607		
11	Carbon dioxide	1.0	Crown Glass	1.52		
12	Carbon dioxide	1.0	Flint Glass	1.57		

Result: Brewster's law is verified by determining the Brewster's angles for various materials in different media.

Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PSO1** are attained.

Signature of Faculty with date & Remark

Experiment No:
Date:

EXPERIMENT No – 10

HALL EFFECT EXPERIMENT

Aim:
1. To determine the Hall voltage developed across the given sample material.
2. To determine the Hall coefficient & the carrier concentration of charge carriers in the given sample material

Apparatus:
Two solenoids, Constant current supply, four probe, Digital gauss meter, Hall Effect apparatus (which consist of Constant Current Generator (CCG), digital milli voltmeter and Hall probe).

Theory:
If a current carrying conductor placed in a perpendicular magnetic field, a potential difference will generate in the conductor which is perpendicular to both magnetic field and current. This phenomenon is called Hall Effect. In solid state physics, Hall Effect is an important tool to characterize the materials especially semiconductors. It directly determines both the sign and density of charge carriers in a given sample.

Consider a rectangular conductor of thickness ***t*** kept in XY plane. An electric field is applied in X-direction using Constant Current Generator (CCG), so that current ***I*** flow through the sample. If ***w*** is the width of the sample and ***t*** is the thickness. There for current density is given by

$$J_x = I/wt \qquad (1)$$

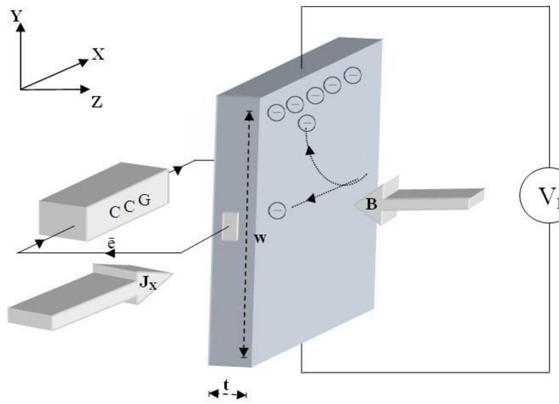


Fig.1 Schematic representation of Hall Effect in a conductor. ***CCG*** – Constant Current Generator, J_X – current density, ***ē*** – electron, ***B*** – applied magnetic field, ***t*** – thickness, ***w*** – width, V_H – Hall voltage

If the magnetic field is applied along negative z-axis, the Lorentz force moves the charge carriers (say electrons) toward the y-direction. This results in accumulation of charge carriers at the top edge of the sample. This set up a transverse electric field E_y in the sample. This develop a potential difference along y-axis is known as Hall voltage V_H and this effect is called Hall Effect.

A current is made to flow through the sample material and the voltage difference between its top and bottom is measured using a volt-meter. When the applied magnetic field B=0,the voltage difference will be zero.
We know that a current flows in response to an applied electric field with its direction as conventional and it is either due to the flow of holes in the direction of current or the movement of electrons backward. In both cases, under the application of magnetic field the magnetic Lorentz force, $F_m = q(vxB)$ causes the carriers to curve upwards. Since the charges cannot escape from the material, a vertical charge imbalance builds up. This charge imbalance produces an electric field which counteracts with the magnetic force and a steady state is established. The vertical electric field can be measured as a transverse voltage difference using a voltmeter.
In steady state condition, the magnetic force is balanced by the electric force. Mathematically we can express it as

$$eE = evB \qquad (2)$$

Where 'e' the electric charge, 'E' the hall electric field developed, 'B' the applied magnetic field and 'v' is the drift velocity of charge carriers.
And the current 'I' can be expressed as,

$$I = neAv \qquad (3)$$

Where 'n' is the number density of electrons in the conductor of length l ,breadth 'w' and thickness 't'.
Using (1) and (2) the Hall voltage V_H can be written as,

$$V_H = Ew = vBw = \frac{IB}{net}$$

$$V_H = R_H \frac{IB}{t} \qquad (4)$$

by rearranging eq(4) we get

$$R_H = \frac{V_H * t}{I * B} \qquad (5)$$

Where R_H is called the Hall coefficient.

$$R_H = 1/ne \qquad (6)$$

Procedure:
Controls
Combo box
Select procedure: This is used to select the part of the experiment to perform.
1) Magnetic field Vs Current.
2) Hall effect setup.

Select Material: This slider activate only if Hall Effect setup is selected. And this is used to select the material for finding Hall coefficient and carrier concentration.

Button
Insert Probe/ Remove Probe: This button used to insert/remove the probe in between the solenoid.
Show Voltage/ Current: This will activate only if Hall Effect setup selected and it used to display the Hall voltage/ current in the digital meter.
Reset: This button is used to repeat the experiment.

Slider
Current: This slider used to vary the current flowing through the Solenoid.
Hall Current: This slider used to change the hall current
Thickness: This slider used to change the thickness of the material selected.

Procedure for doing the simulation:

Part-1. To measure the magnetic field generated in the solenoid

- Select **Magnetic field Vs Current from** the procedure combo-box.
- Click **Insert Probe** button
- Placing the probe in between the solenoid by clicking the wooden stand in the simulator.

Using Current slider, varying the current through the solenoid and corresponding magnetic field is to be noted from Gauss meter.

Trial No:	Current through solenoid	Magnetic field generated
1	1 A	
2	1.5 A	
3	2 A	
4	2.5 A	
5	3 A	
6	3.5 A	
7	4 A	
8	4.5 A	
9	5 A	

Table(1)

Part-2. Hall Effect apparatus

Select **Hall Effect Setup** from the **Select the procedure** combo box

Click Insert **Hall Probe** button

Placing the probe in between the solenoid by clicking the wooden stand in the simulator.

Set "**current slider**" value to minimum.

Select the material from "**Select Material**" combo-box.

Select the Thickness of the material using the slider **Thickness**.

Vary the Hall current using the slider **Hall current**.

Note down the corresponding Hall voltage by clicking "**show voltage**" button.

Then calculate Hall coefficient and carrier concentration of that material using the equation $R_H=V_H\,t / (I \times B)$

Where $\boldsymbol{R_H}$ is the Hall coefficient RH=1/ne

And $\boldsymbol{n}$ is the carrier concentration Repeat the experiment with different magnetic field.

Observations & Readings: - Name of the Material==Germanium

S.No	Thickness in (m)	Hall Current in (mA)	Hall Voltage in (mV)				
			Current 1(A)	Current 2(A)	Current 3(A)	Current 4(A)	Current 5(A)
1	**0.0001**	**1**					
2	**0.0001**	**2**					
3	**0.0001**	**3**					
4	**0.0001**	**4**					
5	**0.0001**	**5**					
6	**0.0002**	**1**					
7	**0.0002**	**2**					
8	**0.0002**	**3**					
9	**0.0002**	**4**					
10	**0.0002**	**5**					
11	**0.0003**	**1**					
12	**0.0003**	**2**					
13	**0.0003**	**3**					
14	**0.0003**	**4**					
15	**0.0003**	**5**					
16	**0.0004**	**1**					
17	**0.0004**	**2**					
18	**0.0004**	**3**					
19	**0.0004**	**4**					

20	**0.0004**	**5**					
21	**0.0005**	**1**					
22	**0.0005**	**2**					
23	**0.0005**	**3**					
24	**0.0005**	**4**					
25	**0.0005**	**5**					
26	**0.0006**	**1**					
27	**0.0006**	**2**					
28	**0.0006**	**3**					
29	**0.0006**	**4**					
30	**0.0006**	**5**					
31	**0.0007**	**1**					
32	**0.0007**	**2**					
33	**0.0007**	**3**					
34	**0.0007**	**4**					
35	**0.0007**	**5**					
36	**0.0008**	**1**					
37	**0.0008**	**2**					
38	**0.0008**	**3**					
39	**0.0008**	**4**					
40	**0.0008**	**5**					
41	**0.0009**	**1**					
42	**0.0009**	**2**					
43	**0.0009**	**3**					
44	**0.0009**	**4**					
45	**0.0009**	**5**					

Hall Coefficient of Germanium= ; & Charge Carrier Concentration in Germanium=

Observations & Readings: - Name of the Material== Gold

S.No	**Thickness in (m)**	**Hall Current in (mA)**	**Hall Voltage in (mV)**				
			Current 1(A)	**Current 2(A)**	**Current 3(A)**	**Current 4(A)**	**Current 5(A)**
1	**0.0001**	**1**					
2	**0.0001**	**2**					
3	**0.0001**	**3**					
4	**0.0001**	**4**					
5	**0.0001**	**5**					
6	**0.0002**	**1**					
7	**0.0002**	**2**					
8	**0.0002**	**3**					
9	**0.0002**	**4**					
10	**0.0002**	**5**					
11	**0.0003**	**1**					
12	**0.0003**	**2**					
13	**0.0003**	**3**					
14	**0.0003**	**4**					
15	**0.0003**	**5**					
16	**0.0004**	**1**					
17	**0.0004**	**2**					
18	**0.0004**	**3**					

19	**0.0004**	**4**					
20	**0.0004**	**5**					
21	**0.0005**	**1**					
22	**0.0005**	**2**					
23	**0.0005**	**3**					
24	**0.0005**	**4**					
25	**0.0005**	**5**					
26	**0.0006**	**1**					
27	**0.0006**	**2**					
28	**0.0006**	**3**					
29	**0.0006**	**4**					
30	**0.0006**	**5**					
31	**0.0007**	**1**					
32	**0.0007**	**2**					
33	**0.0007**	**3**					
34	**0.0007**	**4**					
35	**0.0007**	**5**					
36	**0.0008**	**1**					
37	**0.0008**	**2**					
38	**0.0008**	**3**					
39	**0.0008**	**4**					
40	**0.0008**	**5**					
41	**0.0009**	**1**					
42	**0.0009**	**2**					
43	**0.0009**	**3**					
44	**0.0009**	**4**					
45	**0.0009**	**5**					

Hall Coefficient of Gold= ; & Charge Carrier Concentration in Gold=

Observations & Readings: - Name of the Material==Copper

S.No	**Thickness in (m)**	**Hall Current in (mA)**	**Hall Voltage in (mV)**				
			Current 1(A)	**Current 2(A)**	**Current 3(A)**	**Current 4(A)**	**Current 5(A)**
1	**0.0001**	**1**					
2	**0.0001**	**2**					
3	**0.0001**	**3**					
4	**0.0001**	**4**					
5	**0.0001**	**5**					
6	**0.0002**	**1**					
7	**0.0002**	**2**					
8	**0.0002**	**3**					
9	**0.0002**	**4**					
10	**0.0002**	**5**					
11	**0.0003**	**1**					
12	**0.0003**	**2**					
13	**0.0003**	**3**					
14	**0.0003**	**4**					
15	**0.0003**	**5**					
16	**0.0004**	**1**					
17	**0.0004**	**2**					

18	**0.0004**	**3**					
19	**0.0004**	**4**					
20	**0.0004**	**5**					
21	**0.0005**	**1**					
22	**0.0005**	**2**					
23	**0.0005**	**3**					
24	**0.0005**	**4**					
25	**0.0005**	**5**					
26	**0.0006**	**1**					
27	**0.0006**	**2**					
28	**0.0006**	**3**					
29	**0.0006**	**4**					
30	**0.0006**	**5**					
31	**0.0007**	**1**					
32	**0.0007**	**2**					
33	**0.0007**	**3**					
34	**0.0007**	**4**					
35	**0.0007**	**5**					
36	**0.0008**	**1**					
37	**0.0008**	**2**					
38	**0.0008**	**3**					
39	**0.0008**	**4**					
40	**0.0008**	**5**					
41	**0.0009**	**1**					
42	**0.0009**	**2**					
43	**0.0009**	**3**					
44	**0.0009**	**4**					
45	**0.0009**	**5**					

Hall Coefficient of Copper= ; & Charge Carrier Concentration in Copper=

Result:- Hall coefficient for different materials & their Charge Carrier Concentrations are determined and are given in the below table.

S.No	**Name of the Material**	**Hall coefficient (R_H)**	**Carrier Concentration**
1	Germanium		
2	Gold		
3	Copper		

Conclusion: Course outcomes **CO1 to CO5,** Program outcomes **PO1, PO2, PO9 & PO12** and Program specific outcome **PSO1** are attained

Signature of Faculty with date & Remark

APPENDIX- I
Fundamental Physical constants

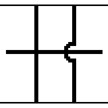
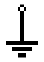
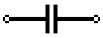
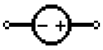
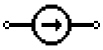
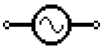
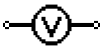
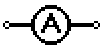
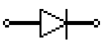
Name	Symbol	Constant Value
Speed of light	c	$2.99792458\ x\ 10^{8}\ m/s$
Planck constant	h	$6.6260755\ x\ 10^{-34}\ J\cdot s$
Planck constant	h	$4.1356692\ x\ 10^{-15}\ eV\cdot s$
Gravitation constant	G	$6.67259\ x\ 10^{-11}\ m^{3}\cdot kg^{-1}\cdot s^{-2}$
Boltzmann constant	k	$1.380658\ x\ 10^{-23}\ J/K$
Avogadro's number	N_A	6.0221 x 10^{23} mol^{-1}
Charge of electron	e	$1.60217733\ x\ 10^{-19}\ C$
Permeability of vacuum	μ_0	$4\pi\ x\ 10^{-7}\ N/A^{2}$
Permittivity of vacuum	ε_0	$8.854187817\ x\ 10^{-12}\ F/m$
Coulomb constant	$1/4\pi\varepsilon_0 = K$	$8.987552\ x\ 10^{9}\ N\cdot m^{2}/C^{2}$
Faraday constant	F	$96485.309\ C/mol$
Mass of electron	m_e	$9.1093897\ x\ 10^{-31}\ kg$
Mass of electron	m_e	$0.51099906\ MeV/c^{2}$
Mass of proton	m_p	$938.27231\ MeV/c^{2}$
Mass of neutron	m_n	$1.6749286\ x\ 10^{-27}\ kg$
Mass of neutron	m_n	$939.56563\ MeV/c^{2}$
Bohr magneton	μ_B	$9.2740154\ x\ 10^{-24}\ J/T$
Flux quantum	Φ_0	$2.067834\ x 10^{-15} T/m^{2}$
Bohr radius	a_0	$0.529177249\ x\ 10^{-10} m$
Earth’s magnetic field	H	0.38 oersted

APPENDIX –II

Physical Density of Metal's & Alloy's

S.No.	Metal or Alloy	Density *(kg/m^3)*
1.	Actinium	10070
2.	Aluminum	2712
3.	Barium	3594
4.	Beryllium	1840
5.	Bismuth	9750
6.	Brass 60/40	8520
7.	Bronze (8-14% Sn)	7400 – 8900
8.	Brass - casting	8400 – 8700
9.	Cadmium	8640
10.	Cast iron	6800 – 7800
11.	Chromium	7190
12.	Cobalt	8746
13.	Copper	8940
14.	Iron	7850
15.	Nichrome	8400
16.	Nickel	8908
17.	Gold	19320
18.	Red Brass	8746
19.	Silver	10490
20.	Stainless Steel	7480 – 8000
21.	Steel	7850
22.	Tin	7280

APPENDIX –III

Symbol	Component name	Physical Meaning
	Not Connected Wire	Wires are not connected
	Earth Ground	Used for zero potential reference and electrical shock protection.
	Resistor	Resistor reduces the current flow.
	Variable Resistor/Rheostat	Adjustable resistor - has 2 terminals.
	Capacitor	Capacitor is used to store electric charge. It acts as short circuit with AC and open circuit with DC.
	Capacitor	
	Variable Capacitor	Adjustable capacitance
	Inductor	Coil / solenoid that generates magnetic field
	Voltage Source	Generates constant voltage
	Current Source	Generates constant current.
	AC Voltage Source	AC voltage source
	Generator	Electrical voltage is generated by mechanical rotation of the generator
	Battery Cell	Generates constant voltage
	Battery	Generates constant voltage
	Voltmeter	Measures voltage. Has very high resistance. Connected in parallel.
	Ammeter	Measures electric current. Has near zero resistance. Connected serially.
	Diode	Diode allows current flow in one direction only (left to right).
	Zener Diode	Allows current flow in one direction, but also can flow in the reverse direction when above breakdown voltage

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